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AUSTRALIAN NUCLEAR SCIENCE AND TECHNOLOGY ORGANISATION

LUCAS HEIGHTS SCIENCE AND TECHNOLOGY CENTRE

Methods for Conduct of Atmospheric Tracer Studies at ANSTO

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Environment Division

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ABSTRACT

A perfluorocarbon atmospheric tracer system has been developed to investigate atmospheric dispersion processes in the region surrounding the Lucas Heights Science and Technology Centre. This report discusses the tracer release, sampling and analysis methods.

1. INTRODUCTION

As part of a study to validate atmospheric dispersion, environmental impact models, an atmospheric tracer capability has been developed at ANSTO. This report discusses the use of the perfluorocarbon family of chemicals for these tracer studies. Four different perfluorocarbon chemicals are available for use in the studies : perfluorodimethylcyclobutane (C_6F_{12} = PDCB); perfluoromethylcyclopentane (C_6F_{12} = PMCP); perfluoromethylcyclohexane (C_7F_{14} = PMCH) and perfluorotrimethylcyclohexane (C_9F_{18} = PTCH). The chemicals are normally stored in liquid form. Even though they are volatile, special release systems containing a small heating oven are required to vaporise the chemicals before their release to the atmosphere.

The use of perfluorocarbon tracers to measure atmospheric transport and dispersion at ANSTO has been described by Stone and Clark (1996). Essentially, at each sampling location, air containing the perfluorocarbon gases is pumped through a small stainless steel tube that contains a chemical adsorbant that removes the gases from the air stream. After the experiment, the perfluorocarbons are desorbed through a Gas Chromatograph-Mass Spectrometer (GC-MS) that produces a unique signature on the chromatogram for each different perfluorocarbon.

This report will detail the perfluorocarbon tracer release methods, the sampling and analysis protocols.

2. ATMOSPHERIC RELEASE, SAMPLING AND ANALYSIS PROTOCOLS

2.1 Pre-Release Activities

2.1.1 Sampling Pumps and Tubes :

If the stainless steel tubes need to be packed with the chemical adsorbant, Hayesep-D, this procedure should be carried out under guidance of the person in charge of the GC-MS (at present David Stone). A measured amount of Hayesep-D needs to be packed in each tube, with plugs at both ends.

Prior to the field study the following is required :

1. The sampling pumps (hereafter typed as samplers or pumps) and chosen adsorption tubes should be matched to give approximate flow rates of 75 ml min^{-1} (i.e. 40 seconds time for the Flowmeter per 50 ml flow).
2. N.B. The intake to the Flowmeter should be connected to a bag of clean Nitrogen gas to prevent contamination of the tubes.

3. The samplers cover two types - Gilian (5 off) and SKC (>20 off , plus ≥5 can be borrowed from Safety). It is the intention to use the 20 Atmospheric Transport Group SKC sampler pumps (numbered from 6 to 25); the five Gilian's and the five Safety pumps can be used as back-up pumps (it has been noticed there is large variability in the flow rates through some of the Safety pumps with the same low flow adaptor attached).

4. **N.B. the pumps obtained from Safety need to be modified for low flow operation by unscrewing the cap on top and then unscrewing the valve below - please refer to the SKC pump manual.**

5. Each of the sampler/tube combinations needs to be calibrated using the Flowmeter. The tubes for this calibration and subsequent field sampling should be attached to the flexible hosing on the inlet to the sampler with the groove on the tube at the atmospheric inlet end. In the case of the Flowmeter calibration, the inlet end of the tube is attached to a Teflon bag containing purified nitrogen gas in order to minimise any possible contamination of the adsorbent tubes by perfluorocarbon gases in the laboratory air. The other end of the tube is attached via flexible tubing to the bottom of the flowmeter angled glass extension. The tube from the top of the Flowmeter is attached to the pump inlet and air is sucked up through the flowmeter.

6. Turn the pumps ON using the instructions in Attachment A.

7. Give a quick squeeze on the rubber bulb at the base of the Flowmeter and watch the bubble rise, timing it between the 0 and 50 ml lines. Repeat this twice and/or to get consistency within 0.5 secs., recording the times in the logbook.

8. Attach the "Standard" adsorption tube (No. 29) and repeat this calibration with procedure 4.

9. Repeat steps 3 to 5 for all twenty (20) sampler pump/tube combinations. (This overall calibration procedure could take 1.25 to 1.5 hours). It may be necessary to repeat this process if a second sampling period is to be performed each day to give two calibrated tubes per sampler.

After each field test only the standard tube is used to re-calibrate the pumps and a correction made for the field tube flow rates versus the standard tube

2.1.2 Background Sampling and Checking the System is "Clean"

Before the samplers are deployed in the field it is important that they are free from any contamination and the background levels of the PFTs in the environment are normal. This is done by always re-calibrating pumps after each field study by connecting the standard tube to the Teflon bag containing pure dry nitrogen.

2.2 Decision Process for Timing of Atmospheric Tracer Release

a) The decision to make a release at Lucas Heights will be determined by the following :
b) The primary aim of the initial releases from Lucas Heights will be to study the atmospheric dispersion of the tracer gas into the Woronora River valley.

c) These releases should be conducted in light, early morning, stable drainage winds when the wind direction is from the north-west to south-west sector.

d) It will be necessary to get a forecast from the Bureau of Meteorology the previous evening which could be something like : "A high pressure system is moving slowly over the region producing very light synoptic scale winds. The local forecast is for light local drainage winds from the west direction over the Sydney basin".

With a favourable forecast, personnel should be on-site by 0530 EST. Using the meteorological data display computer in the Building 44 laboratory, data from the region should be inspected with particular attention being paid to the wind directions at 10m and 49m on the meteorological tower. It is these wind directions that will determine where the field samplers are located downwind/through the valley.

The people involved in the release and sampler deployment should all synchronise their watches to Eastern Standard Time (EST).

2.3 Release of the Atmospheric Tracer

In order to be able to simulate a continuous release from the ANSTO LHSTC and because under light wind conditions the transport of the tracer will be relatively slow, it is suggested the release procedure should be initiated as soon as the decision is taken to conduct the field study. The following is the protocol for a release from the HIFAR active extract/ventilation system.

2.3.1 Notes for HIFAR Active Extract Duct Releases:

a) A Safe Working Permit must be in your possession when working on the release system at HIFAR. - Wear ID and film badge.

b) 2.Contact HIFAR Control Room before commencing and at end of work - #3261.

c) 3.Health Physicist should be present (Bld.42 - in front door at top of stairs #3109) when removing cap from active extract duct inlet to connect vapour outlet from oven and when disconnecting and capping inlet - vinyl gloves are to be worn.

2.3.1.1 "Large" Release System Operation.

Although the strategy for the field study may change with experience, at this stage it is recommended that the PFT is released for 1 hour to simulate a continuous release, but in fact to create a long slug of tracer gas.
To date the perfluorocarbon tracer used has been perfluoromethylcyclohexane (PMCH). This protocol assumes all the equipment is connected.

1. Ring HIFAR Control Room.
2. Check Mains ON and Charger ON - needed because running 2 heaters.
3. TPGO switch to 0(ff). Switch DC System ON.
4. Switch to 2 Heaters and Heater ON.
5. Adjust knob for 130°C when pressing red button on temperature controller. Takes about 3/4 hour to reach temperature.
6. If reading very high, thermocouple plugs making bad contact, pull - reinsert.

7. Flow and Flush switches are adjusted by switching away from Adjust control. Set liquid to 0.50 - this gave 103.3g/h in test with PMCH.
8. Set gas to 0.07 Flush Adjust max clockwise on control.
9. Turn ON N2 gas cylinder and adjust regulator pressure for 350 KPA and open all 4 valves on liquid cylinders.
10. Adjust gas needle valve 6 turns out. If gas flow too low, the oven temperature will drop. If gas flow is too high the back-pressure on the liquid mass flow controller stops it from functioning.
11. Set TPGO switch to P(urgent).
12. **N.B. the purgant is Chloroform that is being released at a rate of approximately 1 ml min^{-1}. At this release rate it should not be a health problem but care should be taken to prevent access of the release output nozzle to the human face area when the purgant is turned ON.**
13. Switch Flush and 2 Flow switches towards Adjust - (operate position). This gives gas flow of about 0.05 +- 0.02- (seems to be too low a rate for control by controller).
14. Open bleed valve on top of liquid mass flow controller 1/2 turn - black knob under top cover of controller - and collect liquid overflow in jar - flow for about 30 seconds - there are always bubbles due to dissolved gas.
15. Close bleed valve and switch Flush switch away from Adjust.
16. Wait for liquid flow to stabilise - at preset (0.50). Takes a few minutes (<5).
17. This is the point at which the vapour outlet is connected to the active extract duct. See note c) above.
18. When flow stable at 0.5 you may commence release - switch TPGO to T(racer).
19. Monitor flow rate from tune to time during release.
20. At end of release switch back TPGO to P(urgent) for 10 minutes minimum.
21. Turn OFF all 4 valves on liquid cylinders.
22. Disconnect from active extract duct - see note c) above.
23. Connect T piece between N2 supply and both gas and liquid inlets - to allow gas to flush all liquid from system.
24. Turn off the gas needle valve (see note 7 above).
25. Turn OFF heaters and DC System ON switch - leave battery on charge to recover.
26. Secure and weather proof system - inform HIFAR Control Room when finished work.

2.3.2 Notes for use of the Portable Release Systems

The portable release systems allow multiple releases of perfluorocarbon tracers from different sources or at different times from the same source.

2.3.2.1 Description

A low cost, portable tracer release system has been developed for easier deployment and release of multiple perfluorocarbon tracer gases. To date we have a capability of releasing PMCH (discussed for the single release system), perfluoro-tri-methyl-cyclohexane (PTCH), perfluoro-methyl-cyclopentane (PMCP) and perfluoro-di-methyl-cyclobutane (PDCB). The portable tracer release system is based on the use of a motor driven syringe to meter the release of a tracer gas. The fluid from the syringe passes through an oven where it is mixed with air from a pump before being released to the atmosphere. Unattended operation is possible with the inclusion of a programmable clock.

The unit is completely self contained and consists of the following : a motor drive for the syringe; a 240VAC inverter for the motor drive; the syringe for the tracer fluid; an electric oven to vaporise and mix the tracer with air; a 6V air pump; two 6V 10AH batteries; a 24 hour, 4 period release control clock and a 240V battery charger.

2.3.2.2 Setting the Control Clock

The typical duration of release is 45 minutes, using the 100(?) ml capacity syringes currently in the release system. Therefore, before a 30 minute sampling period commences, it is only possible to release tracer and establish a "plume" or elongated slug of tracer across the region which is 15 minutes "long". The actual length of the "slug" will be determined by the prevailing wind speed or the average speed through the vertical profile of the "slug" and across the region.

Real Time Hour Set – Press the "PROGRAM" button. All of the time digits will flash and a round symbol is displayed on the left of the screen to show that this is the current time display. Press the "CHANGE" button to advance the hour. Hold the button down to advance more rapidly. The clock is set for 24-hour display.

Real Time Minute Set – next press the "PROGRAM" button and the minutes flash. Advance the minutes as for the hours with the "CHANGE" button.

Program Turn-on Time – next press the "PROGRAM" button and a dot will be seen on the bottom of the display above the " PROGRAM 1"on the timer face and "ON" displayed in the top right hand corner. Set the hours for the first turn on time with the "CHANGE" button. Press the "PROGRAM" button and then set the turn-on minutes with the "CHANGE" button.

Program Turn-off Time – Press the "PROGRAM" button and "OFF" will now be displayed at the bottom right of the screen. Set the hours and minutes as for the "ON" time.

Cancel Program – Step through the options using the "PROGRAM" button until you reach the time you wish to cancel. Press the "CHANGE" button and cycle through the hours display until "- - " is displayed. Then press "PROGRAM" again to cancel that time.

Timer Notes:

* There are 4 ON–OFF time periods, which can be programmed by continuing the sequence as above. If you do not press any buttons for 1 minute the timer reverts to real time display.
* The bottom switch acts as a manual override and can turn the system ON, OFF or controlled by the timer ("TIMED"). **Leave this switch in the "OFF" position** when the unit is not in use to prevent timer activation.
* The "CHANGE" button can also be used to toggle ON and OFF when in the "TIMED" switch position
* All times can be cleared by pressing "CHANGE" and "RESET" together until display blanks out.
* The "PROGRAM" button can be used to revue all times.

2.3.2.3 Charging the Batteries

Plug the unit into the mains. A completely discharged battery should reach full capacity in about 15 hours.

The unit is capable of delivering about 5 hours of release time with a fully charged battery. The battery capacity is 10 ampere/hours and current consumption less than 2 amps.

This time could be increased by operating the mains charger during the release.

The charger does not supply sufficient current for a release if the battery is fully discharged.

2.3.2.4 Loading the Syringe

* Use an empty or water filled syringe to practice if you have not done this before – to minimise escape of the tracers into the atmosphere.
The release fluid can be drawn into the syringe from a beaker or through a small piece of suitable plastic tubing.

Keep the end of the syringe sealed and do not fit to the release system until required for a release; to minimise loss by spilling, evaporation or boiling. Some of the tracer fluids appear to boil in hot weather.

Always keep an air gap in the syringe during storage and especially when fitting to the release system.

Release the syringe plunger drive from the screw thread by squeezing the two release tabs and slide the plunger drive back.

Tilt the release system when fitting the syringe to keep the air gap at the outlet, hold back the spring-loaded retaining clip and fit the syringe to the release system.
Push the tapered inlet (to the oven) hard onto the end of the syringe while holding the syringe body at the finger-holds end – a small twist of the syringe may help to make a good seal.

With the system tilted so that the air gap is at the outlet, push the plunger in to remove the air gap. This should be done as close as practical to the release time or there may be some loss due to expansion.
Release the plunger drive and move to contact the end of the plunger.

2.3.2.5 Tracer Release Notes

* The syringe should be weighed before and after the release to determine the release mass.
* Label the syringes so that their contents are known!
* Leave the lid off the unit in hot weather to reduce the internal temperature.
* If boiling occurs, tilt the system with the outlet at the top, to stop the fluid being driven out by the pressure.
* Keep the gas outlet tubing short to stop condensation of the tracer in the cold tube.
* The air pump is quite a low pressure. If injection into a higher pressure area is required it may be necessary to attach a tube to the inlet of the pump and draw the air from the higher pressure region

The release system uses 240V AC to drive the pump and charge the batteries - BE CAREFUL- when servicing.

2.4 Deployment of the Field Samplers

The sampler locations used to date are noted in Table 1. Two sets of data are presented. The first is according to the AMG66 system (used on current topographic maps). The second is according to the WGS84 co-ordinate system. These were determined using a portable GPS operating in the differential mode; the measured WGS84 values were converted to AMG66 (see Appendix B for instructions on the set-up of the GPS and how the data are subsequently analysed to generate Table 1).

Once a decision has been made to make a release of atmospheric tracer, a pump "START" time has to be chosen. Two factors, the measured wind speeds and the time it takes to deploy the samplers determine this sampler "START" time and the time to commence the tracer release. Winds on the LHSTC tower and on the plateau above the valley are typically higher than in the valley where values of the wind speed under early morning conditions are about 1 m s^{-1}, i.e. ≡ 3.6 km h^{-1}. Thus for a 1.5 h delay to "START" time, this only gives a transport distance of 4.8 km. It should be noted that the distance from HIFAR to the Needles/Sarbugal Pass via the various gullies is approximately 3.65km with another 2.075km down valley to the Shackles Estate site making 5.725km; the distance to Prince Edward Park (PEP) is 8.7km and to the junction of the Woronora River with the Georges River is 12.4km. With a wind speed of 1 ms^{-1}, this means it would take the leading edge of the tracer plume 1hr35min to reach the Shackles Estate, 2hr25min to reach PEP and 3hr27min to reach the Georges River. Samplers will have to be deployed and the "START" time determined accordingly.

Sampler pumps with the attached tubes are pre-programmed to be turned ON at this "START" time for a 30-minute sampling period (see Appendix A for instructions on the programming of the pumps).

The deployment of samplers and the role of the portable Gas Chromatograph (GC) (if available) in determination of this "START" time will be defined on the following basis :

The portable GC will initially be used to define horizontal extent of the plume by driving along the eastern boundary of the LHSTC and across to New Illawarra Rd if necessary. The sampling protocol with the GC is still to be determined but a preference would be to take spot measurements at locations roughly 50-100m apart. The crew with portable GC should have a GPS to define its position for recording in the logbook as well as for later plotting on a map.

Once the general direction of the plume has been determined (in particular the gully/valley into which it is being advected), the field crews with the longer-term samplers can commence operations.

Location of the samplers will be determined by current GC observations and predicted wind direction shifts during the following 1.5 hours or so.

Each person used to deploy the samplers will have the following equipment - a mobile telephone, star pickets, a sledge hammer, wire and side cutters, a can of spray paint, a log book in which the locations are to be identified together with the number of the sampler/tube system.

2.4.1 Person A (Sedan vehicle) :

Immediately after the GC has been used along the boundary, three samplers will be located along that downwind boundary fence and if possible across the plume to give some idea of the initially mixed profile in a horizontal crosswind direction. The person deploying these samplers should also deploy two samplers upwind in order to measure ambient/background conditions.

If the release system is running in a semi-automatic and/or reliable mode then the person looking after the releases could also be person A who deploys these samplers at the LHSTC.

2.4.2 Other Field Crews

The people deploying the samplers in the Woronora river valley require keys to gates, both to the Needles (via Old Illawarra Rd past the Lucas Heights Community School) and to the Water Board pipeline gates (please obtain the Bushfire Brigade, blue alligator key from Geoff Clark). Determining the precise location could prove to be difficult for the people deploying samplers in the Woronora Valley along the Water Board pipeline and down at river level. The best idea is to try to locate these positions on the map by recognition of significant landforms, electricity power lines, odometer readings, other distinguishing features, etc.. Using the spray can, place a small dot which can be found later so that the more precise position can be determined using the GPS instrument. The philosophy behind choice of these sampler locations is the following :

After the portable GC has been used along the LHSTC boundary it could be taken (accompanied by Persons B and C - discussed below) down to the Needles (assuming the tracer is heading for the Woronora valley) or to other higher altitude locations. Before Persons B and C deploy their samplers and determine the "START" times, the GC should be showing indications of the arrival of the tracer plume. From knowledge of the start time of the tracer release, an estimate can be made of the tracer transport speed.

This will be useful for determination of the down valley arrival times for the tracer and the "START" times for the samplers. Persons B and C can then determine the "START" times say 15 or 30 minutes hence, to allow for the time it takes to reach their deployment positions.

All "START" times should be kept consistent with the meteorological data acquisition systems averaging times i.e. on the hour or at 15, 30 or 45 minutes past the hour.

2.4.2.1 Person B (4WD vehicle) :

This person is to look after deployment of the samples along the valley ridge line in Engadine and further down-valley in Woronora Heights. The deployment will be based on information on the winds near the source and from the portable GC measurements closer to the source.

2.4.2.2 Person C (4WD vehicle) :

One strategy might be to place a sampler at river level at the Needles and two at approximately 10m and 50m (vertical elevation) above river level on approach roads to either side of the valley. Look after the river level deployment of samplers by following the Water Board pipeline road, starting at a location near where the tracer is expected to intersect the river (e.g. up-valley of the Needles, depending on wind direction). This person is responsible for the valley sampling, up-river of the tracer plume intersection point (one sampler) and down-river to near the Shackles Estate.

Later in the morning, the portable GC could be driven further down-valley down to say, Prince Edward Park and be deployed there for the remainder of the release or until the plume arrives. Periodic measurements will allow determination of the tracer transport speed and subsequent time history of the tracer concentrations.

2.4.3 Strategy for Sampler Deployment if the Portable GC is not available

If the portable GC is not available then an alternative strategy will be necessary for deployment of the samplers. This will have to be based on the assumed tracer atmospheric transport speed, as well as wind observations from the anemometer network which are displayed in real-time in the Building 44 laboratory.

2.4.4 Physical set-up of samplers

Each sampler should be hooked on to the star picket (near the base) using the supplied wire. The hose with the adsorption tube at the end, should be held in a vertical direction (about 1m above ground level) so that crimping of the tube does not impede the flow down the tube section attached to the sampler inlet.

After deployment of the samplers, do not forget to remove the cap from the intake end of the adsorption tube.
Note : check the rotameter float ball is free to move by inverting the sampler and gently tapping the glass/perspex sampler window.

During the release, the person deploying the samplers should re-visit each site to check that each pump is working by viewing the small rotameter float ball vibrating near the bottom of the glass tube. The minutes remaining or since the pumps started (depending on pump type) should be noted against your watch time when they turn over in order to determine when the pump actually started; there may be small differences due to individual pump idiosyncrasies.

The aim of each morning's sampling is to take two, 30 minute samples, separated by the time it is determined to revisit each sampler site. When the scheduled sample has finished, collect the samplers/tubes and star pickets, place the caps on both ends of the tubes and return them to ANSTO GC-MS laboratory in Building 21.

2.4.5 Communications

As each field crew will have a mobile telephone, it is important to keep in touch during the progress of the field study. Thus sample deployment decisions will be made on the spot with field crews B and C. The PFT sample release person/Crew A will also be in close touch with the study director regarding PFT release duration, current meteorological conditions, etc..

2.5 Analysis Methods following a Field Test

2.5.1 GC-MS operations :

I t should be emphasized that the operation of the GC-MS requires detailed instruction from the GC-MS specialist (at present Dr. David Stone) and even then the unexpected might still happen for which this knowledge is required.

2.5.1.1 Setup of Negative Chemical Ionisation (NCI) source for GC-MS

- Procedure used if Electron Impact source is currently installed (the default GC-MS operation)
- Press 'Esc' on the GC-MS computer several times until at the top level of the data acquisition and processing program, (indicated by LAB BASE at bottom right of screen).
- Turn operate to off by typing **'A'**, **'M'**, **'S'** **'O'**, and toggle the **ON/OFF** to **OFF** in bottom left of screen using left or right mouse button or typing 'OFF' and enter
- Turn source temperature to 30C by typing **'A'**, **'M'**, **'T'**, select (type) **ST** and enter **30.**
- Check methane (CI gas) is connected, open valve and flow regulator, set 20 psi on gauge
- Release vacuum by typing **'A'**, **'M'**, **'S'** **'C'** and toggle the **OFF /ON** to on (type 'ON' enter)
- Wait 15 seconds and type **'A'**, **'M'**, **'S'** **'C'** and toggle the **OFF /ON** to off (type 'OFF' enter)
- Turn off Vacuum pump **'A'**, **'M'**, **'S'** **'V'** and toggle the **OFF /ON** to off (type 'OFF' enter)
- Wait till machine switches off and then till air is heard to stop entering the machine
- Using 2 small spanners provided, slacken 1/16" swagelock nut and withdraw column from Mass Spectrometer source transfer line, (found inside GC oven on RHS).
- Disconnect column (if not Carbograph-1 as used for PFT analysis) by carefully removing from press-fit glass connector about 1-2 coils from injector end (other end from Mass Spec)
- Install Carbograph-1 column by reversing previous step, but do not insert end of column into transfer line. Ensure column pressure is at 5 psi (0.32 mm) or 14 psi (0.22mm column)
- Close oven door and set temperature to 60C for 5-10 minutes, proceed with next steps
- Remove top left and bottom right thumb/finger-tight black nuts on source Cover plate situated in lower front centre of Mass Spectrometer, (15cm square aluminium plate). Remove plate
- Remove the Electron Impact source (consult user manual) and exchange with the NCI source
- Ensure thermocouple connections are correctly made before replacing source plate.
- Tighten thumb nuts to snug only, ensuring the plate is perfectly central

- Turn oven off and position end of column carefully into transfer line, secure the swagelock firmly
- Restore vacuum **'A', 'M', 'S' 'V'** and toggle the **OFF /ON** to on (type 'ON' enter)
- Set source to negative CI by **'A', 'T', 'M', 'IO'** and toggle the **+EI** to **-CI** (left mouse button)
- Wait 15 minutes ensuring vacuum is attained (source and analyser to read –4.0) and source temp. of 200C (ST) is reached by observing read-backs, **'A', 'T', 'M',** in mid left hand side of screen
- Set computer to acquire NCI data, **'A', 'I', 'M'** select the box in top right corner and left-click 5 times to 'PMCH_NCI'
- Check the parameters on mid right side are **MSM:** SIR and **MSF:** SIRTEST2
- Tune Mass Spectrometer from the tune page **'A', 'T', 'M',** Toggle **Operate** to **ON,** and toggle **Ref Gas** to **ON.** Set **DM** (multiplier) at top right to **900**, enter
- Turn **methane control valve** (left side of Mass Spectrometer) 3 to 4 turns clockwise, and observe shape and height of peaks in three windows on centre right side. Adjust methane plus/minus half turn to optimise peak height
- Adjust parameters QIE and SF1-SF4 for optimum peak shape
- Turn off **Operate** and **Ref Gas,** turn off methane. Leave overnight /weekend to stabilise. Retune.

2.5.1.2 Analysis of the sample tubes on the GC-MS.

It is assumed that the GC-MS and desorber equipment have been configured for Negative Chemical Ionisation (NCI), adjusted and are ready for operation. Note the layout of the computer, desorber, GC and Mass Spec. from left to right in the Laboratory.

- Press 'Esc' on the GC-MS **computer** several times until at the top level of the data acquisition and processing program, until LAB BASE appears in bottom right hand corner of screen
- Type 'A', 'I', 'G' into **computer**. File display should read 'PMCH_NCI' – Press 'Enter'
- Type the distinctive name of the test file - this name includes the number of the tube to be tested and must be less than 9 characters ie KA05TU56 - then press 'Enter'. (Tube 56, KAAL set 5)
- The **GC** displays 'READY' after the file loads from the computer- providing the Gas Chromatograph (GC) temperature is correct. If it is too hot it will display 'Press START when READY' – leave the door open to hasten cooling until 'READY' is displayed.
- Remove the tube end-caps and place the tube to be tested in the **Thermal Desorber** with the marked ring (inlet end) to the rear.
- On **Desorber**, press 'O'perate, 'E'nter – to begin desorption.
- Turn the **GC** oven 'OFF', middle right of panel
- Open the **GC** door and unhook the first loop of the line. Place about 2cm of this loop in a polystyrene tray and heap a small quantity of dry ice on the line. This needs to be observed

- After 1min., 50sec. Has elapsed on the **desorber** display, turn the inlet valve on the **GC** from the red mark at 8 o'clock position to the red mark at 11 o'clock.
- When the **desorber** beeps at 2 min. on it's display, press start on the **GC**, top right on panel
- When the time on the **GC** is 0.75 min. (Note: decimal of minutes – NOT seconds) remove the line from the dry ice and place back on its holder. Remove the polystyrene and close the **GC** door.
- At 1.00 min. on the **GC** turn the valve back to the 8 o'clock position.
- Turn the **GC** oven on by pressing **'oven temp'** (bottom left of panel) and **30,** press **enter**
- Press 'STOP' on the **GC** after 12.00 min.
- This completes the data acquisition process for this tube.
- To prepare to test the next tube, remove and cap the last tube.

An example of the gas chromatogram is shown in Figure 1.

2.5.1.3 GC-MS calibration

The GC-MS was calibrated by preparation of PFT/nitrogen standards using a method of bag dilutions:
Perfluorocarbon Standards are prepared by dilution of the BNL std (5ppb) in the range 1.67 to 500 ppt (dilution by 3000, 1000, 300, 100, 30 and 10 times) into a set of 3 litre Tedlar bags. Sample was taken from each bag in turn to perform the calibration tests, by connecting the standard desorbtion tube to the desired calibration standard and withdrawing 25 ml using a 25ml syringe. A calibration curve (or curves where necessary) of chromatogram area versus PMCH air concentration was developed. These Tedlar bags were stored so that the GC-MS system could be re-calibrated at regular intervals before, during and after analysis of the field samples. In this way any drift of the instrument calibration could be checked and corrected.
Notes:

a) In early tests a known small amount of PMCH liquid was evaporated and diluted using a measured volume of dry nitrogen gas. The initial bag of gas concentration was then diluted into other concentrations and bags until the range of expected environmental air concentrations was achieved.
b) After the 5 ppb perfluorocarbon gas standard (containing a number of different PFCs) was obtained from Brookhaven National Laboratory, gas was directly injected into a bag by syringe.

2.5.2 Sampler Pump Tests :

1. After completion of the field study, flow rates on all sampler pumps should be checked with the Standard tube. The Flowmeter should be used according to the methods in Section 2.1 above, with at least two checks per sampler to ensure consistency. The reason for these checks is to identify any potential problems with the sampler pumps in order that the GC-MS analyses can be interpreted correctly.

2. When analysis of the adsorbent tubes is complete, flow rates through these tubes could also be re-checked by the same method. This enables final average flow rates and therefore volumes of air drawn through the adsorbent tubes to be determined.

However, the preference is to use the tube correction factors determined in the extensive pre-study measurements. This only requires post-study measurements with the standard tube.

3. At this stage the sampler/tubes are ready for redeployment. If any of the samplers show a deterioration in performance (e.g. slowing of flow rates, etc.) they should be replaced with the battery being discharged followed by recharging. At the mid-point of the studies or after about 4 to 5 hours pump operation, all samplers should be fully discharged followed by recharging. Reference can be made to the appropriate charger manuals for pumps 1 to 25 and turn "ON" the Safety pumps until discharged followed by charging with the Safety charger unit.

2.5.3 Explanation of Tracer Sampling and Analysis Spreadsheets

There is now a brief discussion of the summary spreadsheets showing the atmospheric tracer sampling locations and analyses (see Table 2 below as an example). Each sampler location in the region has been assigned a receptor index (Rec. Index) (see Table 1). The Latitude and Longitude in UTM (m) co-ordinates in the spreadsheets are with reference to the AMG66 datum. The start time for the 30-minute sampling period is in EST. The sample tubes are matched to each pump according to the pre-release calibrations. Before and after each experiment the pumps are calibrated with a bubble chamber flow-meter in which the time was measured for a 50ml flow of air using a "standard" tube (number 29) packed with adsorbent chemical. Earlier we had measured the relative flow rates through the "standard" and real sample tubes to determine the Tube Correction factor. This meant that after each experiment the sample tubes could be taken away for analysis and the pumps could be quickly re-calibrated using the "standard" tube. The calculated volume of air sampled by each pump during the 30-minute period allowed the air concentration of PMCH to be determined after analysis of the sampler tubes on the GC-MS.

The relationship of PMCH air concentration in ppt (parts by volume per trillion) versus pgm^{-3} [pico (10^{-12}) grams per m^{-3}] is as follows :

$$1 \text{ ppt PMCH} = [(1 \text{ pgm}^{-3})/1000]*(22.4/350) \text{ where pgm}^{-3} = 10^{-12} \text{ gm}^{-3}.$$

where the atomic mass of PMCH is 350.

Other perfluorocarbon gases would have equations modified by their molecular weights e.g. PDCB = 300; PMCP = 300; PTCH = 450.

Ambient or background air concentrations have been estimated by Stone and Clark (1998) to be 6 x 10^{-11} gm^{-3}. However, to some extent this is determined by the GC-MS sensitivity and may vary from experiment to experiment. In addition, if two experiments or field releases of PMCH are conducted in quick succession, there may be elevated background levels due to re-circulation of perfluorocarbon tracers through the region of interest by the cyclical/diurnal weather patterns.

The atmospheric dilution factor is calculated as $\chi u/Q$ (m^{-2}) where χ is the air concentration, u is the estimated average transport or wind speed and Q is the release rate. With the plume dispersing over complex terrain where wind speeds are variable, an estimate was made of the average speed from stations between the source and receptors and through the duration of the release. Then an estimate of the dilution factors could be made at the different receptors for each experiment.

3 REFERENCES

Stone, D.J.M., Clark, G.H. 1996 : Perfluorocarbon tracers in atmospheric dispersion studies in Australia. Conference "2000 then what?" Proc. 13th International Clean Air & Environment Conference, Adelaide, Australia. September 22-25. pp. 559-564.

Rec.	LOCATION	UTM E	UTM N	UTM E	UTM N	Long	Lat	Long	Lat	Altitude
Index		GPS	GPS	AMG	AMG	GPS	GPS	AMG	AMG	
1	"Central" position downwind of B.34	314572	6230700	314465	6230509	150.991094	-34.048012	150.989913	-34.049590	128.5
2	"E" position downwind of B.34	314670	6230834	314564	6230643	150.992194	-34.046822	150.991013	-34.048400	139.8
3	"S" position downwind of B.34	314497	6230709	314391	6230518	150.990294	-34.047918	150.989113	-34.049496	134.2
4	100m from Int. Water Board and Heathcote Rds	315297	6228217	315190	6228026	150.998418	-34.070520	150.997237	-34.072098	84.9
5	20m from New Illawarra Rd, Centre plume	314601	6231047	314495	6230857	150.991492	-34.044881	150.990311	-34.046459	149.9
6	Above Woronora Bridge across Heathcote Rd	315032	6228844	314926	6228653	150.995691	-34.064822	150.994510	-34.066400	60.1
7	Akuna Oval, Bangor	318846	6233849	318740	6233659	151.038038	-34.020368	151.036859	-34.021946	103.6
8	Ansto pipeline track at river level	314903	6229785	314797	6229594	150.994494	-34.056318	150.993313	-34.057896	50.0
9	Ansto pipeline track west and above river	314150	6230005	314044	6229815	150.986387	-34.054193	150.985206	-34.055771	151.5
10	ANSTO swimming pool	314414	6230699	314308	6230509	150.989393	-34.047985	150.988212	-34.049563	140.0
11	B.34 fence, ANSTO	314524	6230856	314418	6230666	150.990618	-34.046589	150.989437	-34.048167	143.3
12	Bangaroo Rd/Power line, Menai	318089	6234222	317982	6234031	151.029911	-34.016883	151.028731	-34.018461	100.0
13	Barden Rd, under HT powerline	316835	6233294	316728	6233104	151.016143	-34.025021	151.014963	-34.026599	108.2
14	Barden Ridge oval, near LHCS	315957	6237165	315851	6236975	151.007464	-33.989976	151.006284	-33.991554	35.2
15	Barden Trig	314983	6234060	314877	6233869	150.996267	-34.017800	150.995087	-34.019378	110.7
16	Behind 10 Jaeger Pl., Woronora Heights	317387	6232242	317280	6232051	151.021898	-34.034608	151.020718	-34.036186	89.8
17	Behind 4 Range Pl., under pylon, Engadine	315319	6229707	315212	6229516	150.998972	-34.057094	150.997791	-34.058672	125.2
18	Bottom, Kelton Pl.,Nth Engadine **	316935	6231377	316828	6231187	151.016823	-34.042317	151.015643	-34.043895	90.0
19	Boy's Town	315946	6228797	315839	6228607	151.005570	-34.065398	151.004389	-34.066976	174.9
20	Chadwick St., NE of cnr of Bldg 16	314293	6230577	314187	6230387	150.988057	-34.049063	150.986876	-34.050641	141.9
21	Cnr Lawrence/Hahn Ave., ANSTO	313956	6230313	313849	6230122	150.984341	-34.051391	150.983160	-34.052969	150.0
22	Cnr. Einstein/Hahn Sts., ANSTO	313955	6230200	313849	6230010	150.984317	-34.052401	150.983136	-34.053979	154.7
23	Cnr. Roentgen/Curie Ave., ANSTO	314120	6230309	314014	6230119	150.986127	-34.051448	150.984946	-34.053026	149.7
24	Cnr. Rutherford/Hahn Ave., ANSTO	313932	6230455	313826	6230264	150.984122	-34.050107	150.982941	-34.051685	141.3
25	E. end of Thomson Ave., ANSTO	314396	6230488	314289	6230298	150.989143	-34.049883	150.987962	-34.051461	141.9
26	E. side Carpark/Child Care Centre, ANSTO	314364	6230806	314257	6230615	150.988864	-34.047020	150.987683	-34.048598	137.9
27	EDL/Old LH Tip, north of HT powerline	315074	6233010	314967	6232819	150.997019	-34.027280	150.995839	-34.028858	111.6
28	End of Fairview Ave, Engadine	315404	6228467	315298	6228276	150.999640	-34.068286	150.998459	-34.069864	144.2
29	End of Windle Rd, Menai (view power line)	315641	6233709	315534	6233519	151.003305	-34.021071	151.002125	-34.022649	84.8
30	Extension Forum Rd, Heathcote near HT	315515	6227776	315408	6227586	151.000686	-34.074525	150.999505	-34.076103	135.7
31	Fermi/Einstein Aves, S. of HIFAR	313632	6230139	313525	6229949	150.980796	-34.052893	150.979615	-34.054471	160.8
32	Ferntree Reserve, Engadine	315456	6229225	315350	6229034	151.000364	-34.061463	150.999183	-34.063041	149.8
33	Int. ANSTO track/Water Board pipeline road	315144	6229909	315038	6229719	150.997121	-34.055241	150.995941	-34.056819	65.0
34	Holmlea Pl., North Engadine	315999	6230465	315892	6230274	151.006496	-34.050382	151.005316	-34.051960	139.8
35	House below Bundanoon Rd, east side of river	316835	6231641	316728	6231451	151.015796	-34.039920	151.014616	-34.041498	19.9
36	Illuta Pl., Engadine	315313	6229982	315207	6229792	150.998976	-34.054606	150.997795	-34.056184	115.7
37	Inside HIFAR security fence, NE B.23A, ANSTO	313709	6230314	313602	6230123	150.981667	-34.051338	150.980486	-34.052916	153.7
38	Int Ferntree hill Rd and pipeline road	315275	6228712	315169	6228521	150.998295	-34.066055	150.997114	-34.067633	86.4

Table 1 : Sampler locations

Rec.	LOCATION	UTM E	UTM N	UTM E	UTM N	Long	Lat	Long	Lat	Altitude
Index		GPS	GPS	AMG	AMG	GPS	GPS	AMG	AMG	
39	Int. Barden Rd/New Illawarra Rd, Menai	316122	6233393	316015	6233202	151.008445	-34.024012	151.007265	-34.025590	107.3
40	Int. New Illawarra/ANSTO Entrance Rds.	314297	6230880	314191	6230689	150.988165	-34.046341	150.986984	-34.047919	130.0
41	Int. Sarbugal Pass track/Water Board road	315632	6230752	315525	6230562	151.002583	-34.047722	151.001403	-34.049300	64.2
42	Int. Sierra/Ridge rds., Engadine	315335	6230489	315228	6230299	150.999311	-34.050040	150.998131	-34.051618	113.4
43	Int. Water Board and Needles Rd, above river	315855	6230834	315749	6230644	151.005025	-34.047022	151.003845	-34.048600	22.5
44	Jaeger Pl., Woronora Heights (S.N.43603)	317436	6232241	317330	6232051	151.022439	-34.034617	151.021259	-34.036195	100.1
45	LH Community School	315847	6232024	315741	6231834	151.005190	-34.036295	151.004010	-34.037873	124.3
46	Liverpool/Heath. Rd, park bay bot. str.sect. N.Ill Rd	313727	6229898	313620	6229708	150.981773	-34.055082	150.980592	-34.056660	109.2
47	Liverpool/Heath. Rd, park bay bot. W. side Wor. Riv	315077	6229234	314970	6229043	150.996251	-34.061315	150.995070	-34.062893	39.8
48	Lucas Heights CS, opp boom gate to W of bldgs.	315867	6231925	315760	6231734	151.005375	-34.037199	151.004195	-34.038777	128.9
49	McKenzie Pl/Power line, Menai	315677	6235141	315570	6234951	151.003997	-34.008170	151.002817	-34.009748	88.9
50	Menai Town Centre	316862	6234433	316755	6234243	151.016674	-34.014759	151.015494	-34.016337	114.9
51	Meteorological Tower, ANSTO	313790	6230254	313683	6230063	150.982531	-34.051893	150.981350	-34.053471	154.0
52	Near Water Tank/Reservoir, Lucas Heights	315332	6231577	315225	6231387	150.999509	-34.040233	150.998329	-34.041811	154.1
53	Needles Rd above northside of river	315973	6231259	315867	6231069	151.006384	-34.043219	151.005204	-34.044797	0.0
54	Needles Rd, east side of River	315956	6230879	315849	6230689	151.006118	-34.046634	151.004938	-34.048212	1.0
55	Needles road, int. track, west side of river	315944	6230694	315838	6230503	151.005959	-34.048308	151.004779	-34.049886	79.8
56	Needles Tack, half way down W side OH power	315858	6231084	315752	6230893	151.005110	-34.044778	151.003930	-34.046356	10.2
57	NW corner boundary fence, LHRL	313393	6230413	313287	6230223	150.978277	-34.050381	150.977096	-34.051959	156.0
58	OH Pylon #216, behind 9 Alpine, Pl, Engadine	315286	6230161	315179	6229971	150.998711	-34.052988	150.997530	-34.054566	129.8
59	Old LH tip, L.H. Reservoir Tank visible	315800	6232318	315694	6232127	151.004743	-34.033645	151.003563	-34.035223	107.9
60	Old tip near Pylon (view of water reservoir)	314947	6232243	314841	6232053	150.995484	-34.034169	150.994304	-34.035747	134.0
61	On Blue Trail, West of plume centre	314887	6231312	314781	6231121	150.994645	-34.042552	150.993465	-34.044130	138.5
62	On fence opp. Building 64 carpark, ANSTO	314433	6230347	314327	6230157	150.989524	-34.051161	150.988343	-34.052739	141.2
63	On Old Illawarra road opp. Building 9, ANSTO	313854	6230569	313748	6230379	150.983302	-34.049057	150.982121	-34.050635	139.4
64	Opp D3 on Hahn Ave., ANSTO	313948	6230384	313841	6230194	150.984270	-34.050741	150.983089	-34.052319	145.7
65	Opp. Bulding 67, outside fence, ANSTO	314406	6230459	314299	6230268	150.989245	-34.050155	150.988064	-34.051733	141.3
66	Opp. Int Roentgen/Thomson, near CSIRO delivery	314104	6230456	313998	6230266	150.985985	-34.050120	150.984804	-34.051698	143.6
67	Opp. Int. David Rd/Underwood Pl, Barden Ridge	316521	6232492	316414	6232301	151.012575	-34.032203	151.011395	-34.033781	96.8
68	Parking Bay, Rutherford Ave, near HIFAR ent.	313727	6230366	313620	6230176	150.981873	-34.050864	150.980692	-34.052442	151.5
69	Parking lot north of B.1, ANSTO	314047	6230585	313941	6230395	150.985395	-34.048947	150.984214	-34.050525	137.9
70	Water Board road, NE of Ferntree, near pump A33	315154	6229704	315048	6229514	150.997195	-34.057084	150.996014	-34.058662	80.1
71	Power pylon, behind Building 34	314639	6230871	314533	6230680	150.991866	-34.046483	150.990685	-34.048061	146.2
72	Shackles Estate at river level	317250	6232995	317144	6232804	151.020583	-34.027797	151.019403	-34.029375	10.2
73	Strassman Cres, NE of Bldg 23B	313736	6230236	313630	6230045	150.981953	-34.052046	150.980772	-34.053624	156.2
74	Tap/hose on grass NE B.76, ANSTO	314214	6230612	314108	6230421	150.987209	-34.048742	150.986028	-34.050320	138.6
75	Top of Old Illawarra Rd near Liverpool/Heathcote	312827	6230085	312720	6229894	150.972067	-34.053245	150.970886	-34.054823	162.7
76	Turning circle on Sarbugal Pass-above Needles	315599	6231209	315492	6231019	151.002322	-34.043597	151.001142	-34.045175	40.0

Table 1 : Sampler locations

Rec.	LOCATION	UTM E	UTM N	UTM E	UTM N	Long	Lat	Long	Lat	Altitude
Index		GPS	GPS	AMG	AMG	GPS	GPS	AMG	AMG	
77	Valley NE Barden Trig, under HT powerline	315435	6234235	315328	6234044	151.001186	-34.016302	151.000006	-34.017880	47.3
78	Valley under HT powerline, opp. Cement Pl	314807	6231616	314700	6231426	150.993833	-34.039789	150.992653	-34.041367	126.2
79	Water Board Rd., towards Bundanoon Rd.	316716	6231160	316609	6230969	151.014406	-34.044243	151.013226	-34.045821	29.8
80	Water Board road, gate further SW of Sarbugal track	315205	6230589	315099	6230399	150.997935	-34.049116	150.996755	-34.050694	69.8
81	Water Board road, NE of Ferntree, below pylon	315273	6229221	315166	6229031	150.998371	-34.061458	150.997190	-34.063036	80.2
82	Prince Edward Park, Woronora	319206	6232818	319100	6232628	151.041713	-34.029730	151.040534	-34.031308	0.0
83	River level, below Sarbugal pass turn circle	315622	6231328	315515	6231137	151.002596	-34.042537	151.001416	-34.044115	1.0
84	River level, below water pump station	316310	6231079	316203	6230888	151.009993	-34.044902	151.008813	-34.046480	5.2
85	Pipeline Rd, 1/2 way SW Sarbugal Gate to pump A33	315086	6230190	314980	6230000	150.996554	-34.052698	150.995373	-34.054276	39.9
86	S N. Illawarra Rd, under HT, E of plume centre	314671	6230968	314565	6230778	150.992225	-34.045612	150.991044	-34.047190	145.0

Table 1 : Sampler locations

Rec.	Location	Latitude	Longitude	Start	Pump	Tube	Flow	Flow	Tube	Volume	Chromatogram	Air Concentration		Atmos. Dil.
Index		N UTM (m)	E UTM (m)	Time			Before	After	Correction	per 30 min	Area	(pg/Nm^3)	(ppt)	Factor
7	Akuna Oval, Bangor	6233659	318740	0800	18	22	35.09	34.86	0.865	2226	0.444	207.8	0.013	2.63E-08
13	Barden Rd, under HT powerline	6233104	316728	0800	17	20	35.23	35.48	0.824	2098	39.141	22,238	1.423	2.81E-06
27	EDL/Old LH Tip, north of HT powerline	6232819	314967	0800	3	36	34.22	34.36	0.932	2446	2.989	1,372	0.088	1.73E-07
45	LH Community School	6231834	315741	0800	16	25	34.23	35.43	0.895	2313	3.176	1,543	0.099	1.95E-07
50	Menai Town Centre	6234243	316755	0800	20	13	36.64	36.75	0.888	2178	16.557	8,925	0.571	1.13E-06
59	Old LH tip, L.H. Reservoir Tank visible	6232127	315694	0800	2	32	33.42	33.10	0.874	2365	47.278	23,868	1.528	3.02E-06
75	Top of Old Illawarra Rd near Liverpool/ Heathcote	6229894	312720	0800	7	11	32.35	32.32	0.867	2413	1.151	524.8	0.034	6.63E-08
78	Valley under HT powerline, opp. Cement Pl	6231426	314700	0800	1	27	34.04	34.55	0.839	2202	405.5	221,663	14.186	2.80E-05
54	Needles, east side of River	6230689	315849	0802	15	1	34.24	34.28	0.816	2144	0.969	494.2	0.032	6.25E-08
15	Barden Trig	6233869	314877	0815	19	10	35.16	35.34	0.818	2089	0.648	332.6	0.021	4.20E-08
34	Holmlea Pl, Nth Engadine	6230274	315892	0815	14	Ha I	35.25	35.16	0.761	1945	3.504	2,026	0.130	2.56E-07
18	Kelton Pl, Nth Engadine	6231187	316828	0821	13	43	35.30	34.91	0.879	2254	0.597	282.5	0.018	3.57E-08
44	Jaeger Pl, Woronora Heights	6232051	317330	0826	12	Ha IV	31.16	30.90	0.778	2257	3.230	1,609	0.103	2.03E-07
5	20m from New Illawarra Rd, Centre plume	6230857	314495	0830	9	15	34.46	34.29	0.820	2147	1748.0	980,663	62.762	1.24E-04
61	On Blue Trail, West of plume centre	6231121	314781	0830	8	9	34.01	33.93	0.889	2355	6.788	3,258	0.209	4.12E-07
86	S N. Illaw. Rd, under HT, E of plume centre	6230778	314565	0830	10	35	34.92	35.09	0.729	1874	2886.0	1,854,768	118.705	2.34E-04
77	Valley NE Barden Trig, under HT powerline	6234044	315328	0832	4	8	36.13	35.68	0.790	1980	0.408	213.0	0.014	2.69E-08
82	Prince Edward Park, Woronora	6232628	319100	0845	11	37	36.91	37.15	0.821	1995	4.420	2,497	0.160	3.16E-07
7	Akuna Oval, Bangor	6233659	318740	0900	18	21	35.09	34.86	0.830	2136	29.311	16,295	1.043	2.06E-06
27	EDL/Old LH Tip, north of HT powerline	6232819	314967	0900	3	17	34.22	34.36	0.767	2013	0.402	206.1	0.013	2.60E-08
75	Top of Old Illawarra Rd near Liverpool/ Heathcote	6229894	312720	0900	6	2	35.03	34.92	0.813	2092	0.598	304.8	0.020	3.85E-08
50	Menai Town Centre	6234243	316755	0901	20	14	36.64	36.75	0.909	2229	0.454	212.6	0.014	2.69E-08
45	LH Community School	6231834	315741	0910	5	34	35.02	35.25	0.901	2308	9.391	4,681	0.300	5.92E-07
5	20m from New Illawarra Rd, Centre plume	6230857	314495	0920	9	Ha II	34.46	34.29	0.857	2244	27.107	14,327	0.917	1.81E-06
61	On Blue Trail, West of plume centre	6231121	314781	0920	8	Ha III	34.01	33.93	0.984	2607	11.947	5,325	0.341	6.73E-07
86	S N. Illaw. Rd, under HT, E of plume centre	6230778	314565	0920	10	19	34.92	35.09	0.900	2314	5828.4	3,034,309	194.196	3.83E-04
15	Barden Trig	6233869	314877	0930	19	Ha V	35.16	35.34	0.748	1910	1.090	626.8	0.040	7.92E-08
77	Valley NE Barden Trig, under HT powerline	6234044	315328	0930	4	7	36.13	35.68	0.820	2055	0.396	198.5	0.013	2.51E-08
30	Extension Forum Rd, Heathcote near HT	6227586	315408	0935	16	12	31.16	30.90	0.852	2471	0.847	372.6	0.024	4.71E-08
30	Extension Forum Rd, Heathcote near HT	6227586	315408	1100	17	28	35.23	35.48	0.852	2169	4.946	2,573	0.165	3.25E-07

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Table 2

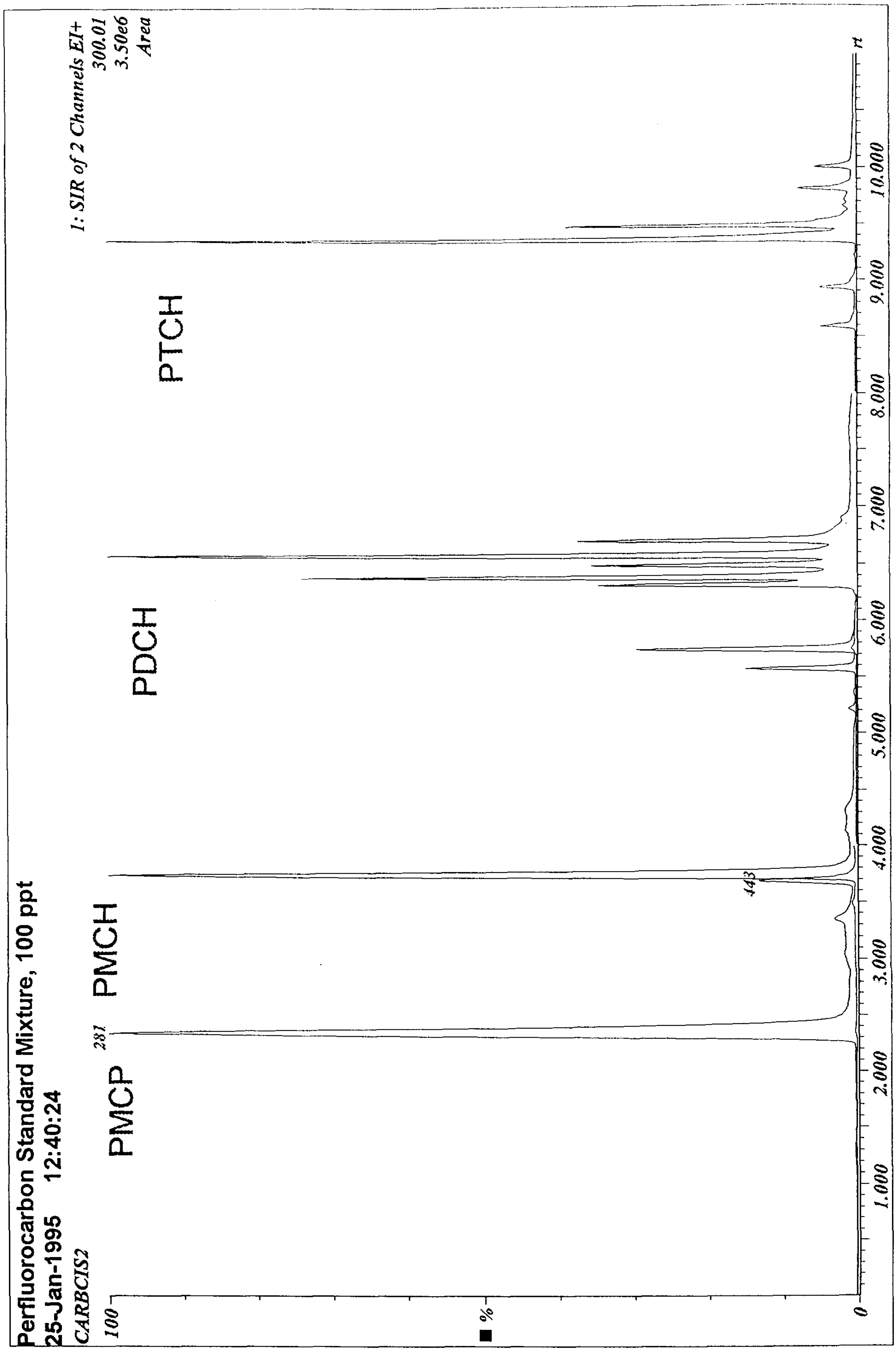
Perfluorocarbon Standard Mixture, 100 ppt
25-Jan-1995 12:40:24
CARBCIS2
1: SIR of 2 Channels EI+
300.01
3.50e6
Area
PMCP
PMCH
PDCH
PTCH
281
443
100
%
0
1.000
2.000
3.000
4.000
5.000
6.000
7.000
8.000
9.000
10.000
rt

Figure 1

APPENDIX A

Programming the Delayed Start and Run Times for the Air Sampler Pumps

A1 GILIAN PUMPS

1. Switch the "Delayed Start Time switch ON.
2. Calculate the start time delay in minutes and enter on the switches using a small screw driver.
3. N.B. the delay and sample times can only be a multiple of 10 minutes on these pumps.
4. Turn the pump "ON" after the start/delay time required i.e. if the sampler turn on time is 1400 EST and it is planned to have a delay time of 90 minutes, the pump should be turned "ON" at 12:30:30 EST*.
5. Confirm the delay time by pressing the "Press Test" button which gives the time remaining to the sampler start time displayed on the LED.
6. Set the run time on the switches (i.e. 30 minutes).

* **N.B.** the Gilian timers seem to increment down the delay start time to the next minute, only 30 seconds after the pump switch is turned "ON". Therefore, some compensation is required.

A2 SKC PUMPS

1. Turn pump "ON" and press the "START/HOLD" button to give HOLD displayed.

2. Press SET-UP to give "DELAYED START" displayed.

3. Increment the value of the flashing digit by pressing the "DIGIT SET" button. Use the "DIGIT SELECT" button to space the flashing digits to the left so that increasing "x 10" minutes can be set.
4. Press the "MODE" button to set the "SAMPLE PERIOD". Repeat Step 3. The "SAMPLE PERIOD" is the total length of the test time. Intermittent sampling can be done by making the "PUMP PERIOD" < "SAMPLE PERIOD". For our case "SAMPLE PERIOD" = "PUMP PERIOD".
5. Press the "MODE" button to give "PUMP PERIOD" displayed. Repeat Step 3.
6. Subsequent pressing of the "MODE" button allows a scan through the pump program sequence.
7. Press the "START/HOLD" button at the beginning of the desired period to give the "DELAYED START" until the pumping is to commence. The time remaining to pump start is displayed and should be checked against watch time.

APPENDIX B

This Appendix gives Instructions on how to operate the GPS in differential mode and describes the method to subsequently analyse the data to give Latitude and Longitude values at the receptor locations in terms of the AMG66 and WGS84 datum systems and UTM and degrees units.

B1 Use of the GARMIN GPS in Differential Mode

1. The Garmin GPS receiver can operate in differential mode using the AUSNAV receiver (Yellow box) and a signal from radio station 2JJJ. It is important that the AUSNAV Licence is current (renewed in August 1999) and that it is operational. If there are problems with either of these aspects, AUSNAV can be contacted on (02) 6238 2007. The Licence No. for the unit/ANSTO is 20-08-33.
2. A complex of leads has been bundled into a bag with only two requiring connections - to a 12 volt re-chargeable battery; to the Garmin GPS.
3. Connection of the aerials depends on the mode of operation : if it is to be portable then connect the small aerial to the Garmin GPS; if it is to be installed in a vehicle with the aerial remote to the GPS unit then attach the aerial with the long lead. The tall white "whip" aerial with the magnetic base is attached to the AUSNAV receiver can be placed on a car roof, magnetic surface or carried as necessary. The green LED in the AUSNAV "yellow" box should be on for 2 seconds and then briefly flash off if operating normally.
4. Turn on the Garmin GPS unit power.
5. Push the SET button allowing sequencing through various menus including the status of the satellite signal screen. After several minutes of acquiring the signals, a small "D" should appear next to the satellite number indicating that it is operating in differential mode.
6. When sufficient signals are received an audible alarm signal will sound; pressing the MSG button can turn this off. A message is then displayed on the screen. Return to the satellite screen by pressing the SET button.
7. Refer to the Garmin GPS Manual to check the operational co-ordinate system e.g. WGS84 or AMG66 - the former is assumed in the following discussion. It is assumed that the units are operated in UTM **not** Latitude/Longitude units, both of which are options.
8. The SURVY button allows data to be received and processed. Initially the CONFIGURATION screen can be navigated by repeated pressing of the ENT button.
9. If the DIFFERENTIAL MODE option is chosen it is important to use the INPUT RTCM MODE and 4800 Baud rate options; if differential operation is not possible or required, turn off the RTCM mode option.
10. When it is time to take a reading, press the NAV button which shows the instantaneous fluctuations in the UTM co-ordinates.
11. Press the SURVY button twice which should bring up the "Begin a New Survey" question. Press the ENT button to proceed.
12. If it is required to change the averaging time, highlight the number (by hitting the ENT key and use the number pad (between the CLR and ENT keys) to type in a new time.
13. Hit the ENT key to commence the averaging; a digital counter will count down the seconds. During this period an indication of the accuracy of the current reading can be obtained from the "SIGMA" value on the screen. This gives an indication of the uncertainty of the results. If it is below 10 m that is a good result.

14. At the end of the averaging period the alarm will sound. This can again be turned off using the MSG button.
15. The SURVY key will show the averaged Easting and Northing (UTM) in metres as well as the altitude. The altitude appears to be the least certain quantity which is measured. Record the results in a log book together with a geographic description of the location (e.g. street numbers).
16. It is necessary to save the average readings as way points before progressing. Next to the WPT display unique alphanumeric characters can be typed. The keys to the right of the screen have multiple meanings (eg. ABC1). Once a key is pressed, the various meanings can be cycled through by using the ← and → keys. By pressing another key on the alphanumeric key pad a second character can be entered to give e.g. A2. When finished press the ENT key twice to store the data.
17. It is recommended that steps 11. To 16. are repeated to give a second set of co-ordinates in order to check repeatability.
18. Turn the unit off by holding down the OFF switch for several seconds.
19. On return from the field, the stored way point data can be retrieved by using the DATA button which highlights the a screen where the way point numbers can be entered using the alphanumeric key pad and the ← and → keys.

B2 Preparation of a Geographic Location Spreadsheet

In order to relate the information collected using the GPS unit, it is necessary to convert from the WGS84 to AMG66 co-ordinate system. Currently all topographic maps and some road directories use the AMG66 system. To do these conversions, the WGS84 readings in UTM (m) units are first converted to Latitude/Longitude (degrees) the following methods are used :

1. Use the Redfearn Excel spreadsheet located on the Building 21, Room 72 computer in file c:\geoff\Redfearn.xls.
2. Double click this file to run the application.
3. Initially it is advisable to check the sheet labelled "Constants and Parameters". These should be set to WGS84. Check the table to the right and if necessary copy across the appropriate values to the highlighted (red) values in the left box.
4. Click on the "E,N Zne to Latitude /Longitude" bar at the bottom of the screen which will allow entry of the various UTM co-ordinates from the survey.
5. Enter the Eastings data in cell E:4 and the Northings data in cell O:4. The Longitude will be displayed in cell F:4 and the altitude in cell P:4.
6. Prepare a listing of the geographic locations and label them from 1 to the total number. Type these into an Excel spreadsheet together with the Longitude and Latitude in degrees to six decimal places (e.g. Table B1). Save this file as a Tab (delimited) text file (****.txt), where the **** indicates a unique filename.
7. Transfer this file to a directory on the Pion computer using the WS FTP95 icon on the desktop window. The Pion directory is : ~ghc/program/utmdeg/zarina.
8. Use the executable program named "gpstoamg66.go" to generate a larger spreadsheet file containing the WGS84 and AMG66 UTM and Longitude/Latitude data.

N.B. The input file name will have to be changed in "gpstoamg66.go" to reflect the recently transferred file (i.e. change the line with fu10=) and the output file name will also have to be unique (i.e. change the line with fu20 =).

9. Transfer this file back to the Desktop computer again using WS FTP95, input to Excel and copy to the spreadsheet containing the geographic information. Format appropriately and save with the Excel Workbook format. Table 1 in the main report is the resulting spreadsheet.

1	150.991094	-34.048012
2	150.992194	-34.046822
3	150.990294	-34.047918
4	150.998418	-34.070520
5	150.991492	-34.044881
6	150.995691	-34.064822
7	151.038038	-34.020368
8	150.994494	-34.056318
9	150.986387	-34.054193
10	150.989393	-34.047985
11	150.990618	-34.046589
12	151.029911	-34.016883
13	151.016143	-34.025021
14	151.007464	-33.989976
15	150.996267	-34.017800
16	151.021898	-34.034608
17	150.998972	-34.057094
18	151.016823	-34.042317
19	151.005570	-34.065398
20	150.988057	-34.049063
21	150.984341	-34.051391
22	150.984317	-34.052401
23	150.986127	-34.051448
24	150.984122	-34.050107
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....		

Table B1