Appendix C Study Design

C.1 Introduction

The detail of the study design is set out in the Study Design and Sampling protocol document (PDP, 2002) and is based on the study brief appended to that document. The study brief required the basic target of the study to be 2,3,7,8-TCDD on the assumption that this is the principal dioxin contaminant of 2,4,5-T, and that its presence would therefore be an indication of escape from the manufacturing process, whether through fugitive emissions, the 1986 incident or breakthrough of TCDD from the incineration of TCDD contaminated waste. While it was recognised that PCDDs and PCDFs are generated by combustion processes (including back-yard burning), such processes generate a broad range of dioxin congeners, with 2,3,7,8-TCDD being a minor or absent component.

From the brief, the study was based on the assumptions that:

1. The former IWD plant was the principal source of dioxin soil contamination in the area;
2. Contamination occurred via discharges to air with subsequent deposition over the residential neighbourhood, and
3. Sampling was to be focused on residential properties, that is, properties to the east and south of the factory. The industrial or reserve land to the north or west of the factory, where previous studies of dioxin contamination have been carried out (TRC, 2001; Pilgrim, 1986), was not to be sampled unless residential properties were identified within the industrial areas, in which case sampling of those properties was to be considered.

The study design considered areas of likely maximum deposition through the review of meteorological data, topography, age and location of residential areas and results of the earlier studies. However, given the considerable community interest in Paritutu, it was important that the study considered not just the likely areas of maximum dioxin deposition, but also the broader residential areas surrounding the plant. The primary study area was therefore defined as the arc of residential properties running from Maui Place and Rangitake Drive to the south-west of the Dow plant, to the residential properties in Findlay and Catherine streets and Ngamotu Road, adjacent to the industrial land to the east. In addition, samples were to be taken from residential areas up to 2.5 km in the predominant downwind directions, and from within or close to any residential land that might be situated within the primarily industrial land to the north and north east of the plant.

Sampling was primarily to measure 2,3,7,8-TCDD in surface soil, which was defined as being between 0 and 75 mm deeper. In addition a small number of deeper samples (75 – 150 mm) were to be taken distributed around the study area to measure deeper effects.

Given that the intent of the study was to measure cumulative effects, it was an obvious requirement to target areas that had been minimally disturbed over the period of deposition or since. However, it was also decided to measure concentrations in gardens at a small number of locations distributed about the study area.

C.2 Study Design Considerations

In developing the study design, no attempt was made to calculate dioxin emission rates or to differentiate between the various sources over time, as this was not part of the study brief. It was considered that the current dioxin concentration in soil would represent the majority of the dioxin deposited into the soil over the period of manufacture, given its slow degradation in soil. In addition, the measured dioxin concentrations in the soil were expected to be representative of current exposure of site occupants to dioxin from soil. Further, these concentrations are assumed to be typical of concentrations that occupants may have been exposed to over at least the last 15 years, since 2,4,5-T manufacturing stopped at the plant.

This assumption ignores the deposition of dioxin emitted from the incinerator that the Dow plant still operates. However, resource consent compliance monitoring (reported to TRC by Dow) shows the incineration process is under good control, with very low emissions. These emissions are expected to be a negligible contribution to present-day soil concentrations compared with the plant emissions between 1960 and 1987.

The direction and strength of the wind is a significant factor in the pattern of deposition from air emissions. There are two predominant wind directions in the New Plymouth area. Data were obtained from the National Institute of Water and Atmospheric Research (NIWA) climate database for New Plymouth airport, several kilometres east, and from Omata (the Waireka research farm operated by Dow), a few kilometres south-east, and also from the TRC for a site they operate in Fitzroy. Examination of wind records for a number of periods in the 1970's, 80's and 90' show the wind is predominantly either from the west or from the south-east. Winds from the north are rare and light. Data for the Omata climate station for the five-year period 1976 – 1980 are shown in Table C-1. The wind pattern for the Paritutu area is expected to be similar.

Table C-1: Wind direction, Omata, 1976 – 1980

Wind Direction	N	NE	E	SE	S	SW	W	NW	Calm	Total
% of time	6.3	6.2	11.7	23.6	5.8	10.0	21.3	6.8	8.2	100

The south-easterly wind will carry emissions from the factory towards the coast, away from the residential areas to the south, south-east and east of the plant. The westerly winds will tend to carry emissions over industrial properties and the port, but also towards residential areas around Mount Moturoa Domain. Comparatively elevated dioxin

concentrations have previously been reported in these directions (see Pilgrim, 1986 and TRC, 2001). In general, emissions will not tend to be carried towards the residential properties to the south and south-east of the factory site, except during the time (about 13% of the time from the figures above) when the wind is blowing in that direction.

Despite there being a lower likelihood of deposition to the south and south-east of the site, there is considerable community interest in this area. It was therefore a requirement of the study that not only were residential properties in the predominant down-wind direction to be sampled, but also residential areas to the south and south-east of the Dow plant. A lower density of sampling was proposed for the area to the south and south-east than for the area to the east.

While the general expectation was that concentrations would show a trend of decreasing dioxin concentration further from the site, and higher concentrations to the east of the site than to the south, it was recognised that there could also be local concentration variations as a result of particular wind conditions or topographic variations. However, it was not the intention of the study to establish the fine detail of localised concentration "highs" or "lows", as the density of sampling to obtain this sampling would have been well in excess of the resources available. In addition, high-concentration "hotspots" from aerial discharge and deposition over particular small areas were not expected and there was no information to suggest that particular locations should be targeted. Rather, the study was aimed at establishing concentration trends over the general area.

The study design was also not intended to address the potential for "hotspots" as a result of dumped material. This would also require a significantly higher density of sampling. Previous investigations into alleged waste dumps have failed to detect elevated dioxin concentrations in residential areas (TRC, 2001).

A grid-sampling scheme was chosen as an appropriate method to achieve the study objectives.

C.3 Grid design

The choice of grid spacing is inevitably a compromise between a large number of sampling points (to be certain that spatial variability is being measured) and the resources available. A curved grid was chosen, with the sampling points being defined by the intersection of radii and concentric arcs centred about the Dow facility. This arrangement gave a smaller lateral spacing, and therefore more detail, closer to the plant. The grid was positioned so that expected variability as a result of wind direction or topography would be adequately measured. An average grid spacing of around 200 m (equivalent to the length/width of about five to eight residential properties, depending on orientation) was chosen. The resultant grid gave a primary spacing of between about 140 m and 270 m in the transverse direction and radial spacing of 200 m. Intermediate grid points were located in the eastern zone of the sample area, giving a diagonal spacing of about 150 m. This gave more detail where, based on wind patterns and topography, greater deposition could be expected.

The grid was positioned to optimise the coverage of the residential area by rotation of the grid about the Dow plant and to take into account the topography, particularly around Mount Moturoa. The grid was also adjusted at the western end so that the points fell within the area of residential properties.

The outermost arc of grid points is 800 m from the centre of the Dow plant. Based on past sampling (TRC, 2001 and Buckland *et al*, 1998) this was considered to be a reasonable distance over which 2,3,7,8-TCDD might be detected above the New Plymouth background concentration. However, provision was made to collect further samples out to 2500 m to the east of the plant, including four at 1000 m and two each at 1500 m and 2500 m, with the decision whether to analyse these made later.

The resultant grid had 23 primary and intermediate grid points, plus the further eight, more distant, points to the east, up to 2500 m from the centre of the Dow plant.

Information from the community had indicated that a small number of isolated houses are located within the industrial area to the north and north east of the plant. An allowance for four such properties to be sampled was made, the choice to be guided by information received from community groups.

C.4 Sampling Sites

The primary grid samples were located within residential properties, or if no residential properties could be sampled, nearby public lands such as parks. However, for the more distant points, samples were to be taken from public land, but road verges or other land in the immediate vicinity of roads would be avoided. The actual sampling location was to be a property or public space at or near the grid point that:

- is long-established, preferably dating from the 1960's, to maximise the opportunity for deposition of dioxin
- has remained undisturbed, with no major changes to the ground surface – by excavation, filling or cultivation – over that period
- has a current occupier, or an easily-traced previous occupier, who has resided at the property for as long as possible. This gives the opportunity to link this study with the blood serum study (see Section 2) and provide a more reliable site history for each site.
- meets the on-site criteria as set out in Section 4.3

It was decided that that lawn areas would provide the most suitable sampling sites as these will generally have a lower likelihood of disturbance. Garden areas, or areas that were previously garden, are less suitable as turning of soil during gardening is likely to reduce any dioxin contamination by dilution with deeper soil. However, up to six vegetable gardens were to be sampled in addition to lawn areas at selected properties. This was to benchmark gardens that may have received dioxin from:

- direct deposition from the air

- spreading of lawn clippings, or compost containing lawn-clippings, noting that some airborne 2,3,7,8-TCDD may bind to the grass in the vapour phase, and subsequently be cut and removed, rather than falling/being washed into the soil.

The vegetable gardens sampled were distributed as evenly as possible over the study area, with an emphasis on the properties at 400 m and 600 m from the Dow plant.

Public records held by the New Plymouth District Council and the TRC were initially searched to establish a short list of sites within 50 m of each grid point that appear to fit the criteria given above. Inquiries of owner/occupiers were then made (assisted by TRC staff) to ascertain site history and determine whether specific sampling sites were available. Local topography was also taken into account to ensure a site was not unusually sheltered relative to other nearby sites. When a property that fell on a grid point did not meet site criteria, the next adjacent suitable site/property was identified and considered for sampling.

C.5 References

Buckland, SJ, HK Ellis, P Dyke (2000). *New Zealand Inventory if Dioxin Emissions to Air, Land and Water, and Reservoir Source,* Ministry for the Environment, Wellington, March 2000

Buckland, SJ, HK Ellis, RT Salter (1998). *Organochlorines in New Zealand: Ambient Concentrations of Selected Organochlorines in Soils*, Ministry for the Environment, Wellington, Wellington, December 1998

Pilgrim, RC (1986). *Submission to the Committee of Enquiry into Possible Health Effects of Manufacture of Agricultural Chemicals in New Plymouth*, Central Regional Air Pollution Group, Department of Health, Wellington, July 1986.

TRC (2001). *Investigation of Alleged Agrichemical Waste Disposal Sites in New Plymouth*, Taranaki Regional Council, August 2001.