# final report

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## Review of Queensland Department of Primary Industries

## Guidelines for Establishment and operation of Cattle Feedlots

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## TABLES

## 1 INTRODUCTION

This report has been prepared by Holmes Air Sciences for Meat & Livestock Australia. Its purpose is to review the Queensland Department of Primary Industries (QDPI) Guidelines for assessment of cattle feedlots in the light of current information about odour emission rates from feedlots generated during research projects undertaken on behalf of the feedlot industry.

The approach adopted in this report is to compare buffer zones derived from the QDPI Guidelines with the results of dispersion modelling using site-specific meteorological data and odour emission rates based on current measurement technology.

The dispersion model AUSPLUME has been used to predict odour levels in the vicinity of five feedlots, three in Queensland and two in NSW, where there were adequate data on local meteorological conditions and feedlot operational procedures. Results of this dispersion modelling are compared with separation distances calculated from the Queensland Department of Primary Industries Guidelines.

## 2 BACKGROUND TO THE STUDY

In 1989 QDPI published a set of guidelines entitled Queensland Government Guidelines for Establishment and Operation of Cattle Feedlots (referred to in this report as the Guidelines). The aim of the Guidelines was to provide a simple method for determining appropriate separation distances, effectively buffer zones, based on the operational characteristics of the feedlot as well as taking into account site specific features. The Guidelines set out a set of air quality objectives as follows.

| Impact Location | | Objective (Odour Units) |
|---|---|---|
| Large towns | >2000 persons | 0.6 |
| Towns | >100 persons | 0.8 |
| Small towns | >20 persons | 1.0 |
| Rural farm residence | | 2.5 |

The objectives were based on 10-munte average predictions from dispersion modelling undertaken by **Carson and Round (1990)** prior to the release of the Guidelines, as well as field measurements of odour generation rates and observations at existing feedlots. These were used to develop working formulae for estimating cattle numbers allowable on a particular site to satisfy the adopted air quality objectives.

The formulae provided estimates of the allowable cattle numbers (N) for a site at a distance (D) metres from an impact location or the separation distance required for a specific number of cattle. The formulae are:

$N = (D/S)^2$

or

$D = \sqrt{N} \times S$

Where N = Number of cattle

D = Separation distance in metres from pens and stockpiles

S = Composite site factor

= S1 x S2 x S3 x S4

where S1 = stocking density factor

S2 = receptor factor

S3 = nighttime drainage factor

S4 = surface roughness factor

Details on the S factors and some background on the way in which they were calculated and the range of values is contained in the Guidelines.

This procedure allowed the developer to determine whether a proposed feedlot would fit into a specific location. This assessment method is often referred to as a Tier 1 approach. Although originally based on dispersion modelling using the version of the US Industrial Source Code (ISC model) available in 1989, no further modelling was required to assess the development.

This type of approach does not restrict a developer from undertaking a more detailed assessment, using site-specific meteorology and other relevant factors. However it removes the necessity to do this, which can be beneficial to smaller developers.

The Feedlot Industry maintained that there was a need to validate the data used in the formulation of the Guidelines and adopted a position whereby they agreed to the implementation of the Guidelines on the proviso that appropriate research work was undertaken to prove or disprove the validity of the data used and that such information, when available, be used to review the Guidelines.

Extensive research was conducted by QDPI between 1989 and 1995 within the Meat Research Corporation funded DAQ.064 and DAQ.079 projects. As part of these projects, data sets of odour emission rates were collected for feedlot pens and effluent ponds along with a substantial amount of other relevant information.

More recently the Guidelines have been revisited and a new draft provided, essentially in very similar form on the basis that since their adoption in 1989 there has been a reduction in the number of complaints about feedlots.

Comments by the Australian Lot Feeders Association (ALFA) on the draft version of the Environmental Guidelines questions the validity of this approach and highlights the need for complete revision of the methods given the changes that have occurred since the original exercise was undertaken. ALFA further argues that the reduction in complaints may in fact be due to the fact that the method over estimates separation distances and that it is also likely that better management of feedlot facility have played a major contributing factor.

The purpose of this report is to try to resolve this issue. To this end, detailed dispersion modelling has been undertaken for five existing feedlots in NSW and Queensland where on-site meteorological data have been collected and there is available information on operating procedures. Model predictions are then compared with separation distances.

Odour emission rates that are consistent with current odour measurement and sampling methodology have been used to predict the levels of odour impact in the vicinity of the feedlot. An approach has been adopted which considers odour goals that are consistent with those currently in place for other agricultural activities such as chicken farms and composting processes. It is recognised that given the different quality of odours and potentially different levels of offensiveness of the odour, each industry is likely to require its own set of odour criteria. It is nevertheless useful to determine whether the model predictions for feedlots are within the "ballpark" of predictions and criteria for other agricultural industries.

# 3 REVIEW OF ODOUR CRITERIA

This section discusses air quality goals relating to odour and the way in which odour is measured. It should be noted that there is still considerable debate in the scientific community about appropriate odour goals as determined by dispersion modelling.

## *3.1 Odour measurement*

Odour is measured using panels of people who are presented with samples of odorous gas diluted with decreasing quantities of clean odour-free air. The panellists then note when the smell becomes detectable. Odour in the air is then quantified in terms of odour units which is the number of dilutions required to bring the odour to a level at which 50% of the panellists can just detect the odour. This process is known as olfactometry.

Olfactometry can involve a "forced choice" end point where panellists identify from multiple sniffing ports the one where odour is detected, regardless of whether they are sure they can detect odour. There is also a "yes/no" or "free choice" end point where panellists are required to say whether or not they can detect odour in the sniffing port, that is, they can say they do not detect odour. Forced choice olfactometry generally detects lower odour thresholds than yes/no olfactometry.

There are variations in the literature in the terminology for odour thresholds. The New South Wales Environment Protection Authority (NSW EPA) has used the definition of the ***detection*** threshold as the lowest concentration which will elicit a response, but where the panellist is essentially guessing correctly. This corresponds to the first end point in the forced-choice olfactometry method. The odour ***recognition*** threshold is the minimum concentration at which the panellist is certain they can detect the odour. This is also referred to as the certainty threshold and is the second endpoint in forced-choice olfactometry and similar to the first end point in yes/no olfactometry.

There is a general move in Europe and Australia to adopting the certainty threshold as the odour standard and referencing this to a standard concentration of butanol (40 ppb). The ratio of recognition to detection threshold (or certainty to guessing) varies but as a general rule is of the order of three.

As with all sensory methods of identification there is variability between individuals. Consequently the results of odour measurements depend on the way in which the panel is selected and the way in which the panel responses are interpreted. The process by which these imprecise measurements are translated into regulatory goals is still being refined.

The determination of air quality goals for odour and their use in the assessment of odour impacts is recognised as a difficult topic in air pollution science. It is true to say that the topic has received considerable attention in the past five years and that the procedures for assessing odour impacts using dispersion models have been refined considerably.

In recent times regulatory authorities have attempted to refine odour goals and the way in which they should be applied with dispersion models to assess the likelihood of nuisance impact arising from the emission of odour. However as discussed above these procedures are still being developed and odour goals are likely to be revised in the future.

There are two factors that need to be considered:

1. what "level of exposure" to odour is considered acceptable to meet current community standards in NSW, and
2. how can dispersion models be used to determine if a source of odour meets the goals.

The term "level of exposure" has been used to reflect the fact that odour impacts are determined by several factors, the most important of which are the frequency of the exposure, the intensity of the odour, the duration of the odour episodes and the offensiveness of the odour (the so-called FIDO factor). In determining the offensiveness of an odour it needs to be recognised that for most odours the context in which an odour is perceived is also relevant. Some odours, for example the smell of sewage, hydrogen sulphide, butyric acid, landfill gas etc., are likely to be judged offensive regardless of the context in which the occur. Other odours such as the smell of jet fuel may be acceptable at an airport, but not in a house, diesel exhaust may be acceptable near a busy road, but not in a restaurant etc.

In summary, whether or not an individual considers an odour to be a nuisance will depend on the FIDO factors as discussed above and although it is possible to derive formulae for assessing odour annoyance in a community, the response of any individual to an odour is still unpredictable. Odour goals need to take account of these factors.

As with all sensory methods of identification there is variability between individuals. Consequently the results of odour measurements depend on the way in which the panel is selected and the way in which the panel responses are interpreted. How these imprecise measurements will be translated into regulatory goals still requires resolution.

### *3.2 Odour goals*

**Table 1** compares the odour goals set by the QDPI in 1989 with goals set recently by the NSW EPA in relation to composting processes, but which have also been applied to other industries. Both sets of goals are based on the results of dispersion modelling. The QDPI goals refer to maximum odour levels consistent with the type of olfactometry used at the time and the NSW goals refer to odour certainty thresholds, to be exceeded not more than 1% of the time, for different sensitive receptors.

The difference between odour goals for different receptor types is based on considerations of risk rather than differences in odour acceptability between townships and single residences. For a given odour level there will be a wide range of responses in the population exposed to the odour. In a densely populated area there will therefore be a greater risk than in a sparsely populated area that some individuals within the community will find the odour unacceptable.

Both QDPI and NSW EPA goals take this into consideration.

**Table 1 – Criteria for assessment of odour impacts**

| **Receptor** | **QDPI 1989 Odour units Maximum** | **NSW EPA 1998 odour certainty units 99% compliance** |
|---|---|---|
| Rural farm residence | 2.5 | 7 |
| 10 | Not specified | 6 |
| 30 | 1.0 | 5 |
| 125 | 0.8 | 4 |
| 500 | Not specified | 3 |
| Urban | 0.6 | 2 |

There are two main differences between the QDPI goals and the NSW EPA goals. They are:

- the level of acceptable odour, which is greater for the NSW goals, reflecting the greater sensitivity of modern olfactometry
- The NSW goals allow exceedances. This represents a philosophical shift in NSW from goals based on no detectable odour to goals based on no offensive odour.

It should be noted that testing for compliance with a frequency-based goal can only be done using real meteorological data collected over one year. The QDPI Guideline approach is therefore limited in this respect.

# 4 REVIEW OF METHODS USED TO DETERMINE ODOUR EMISSIONS FROM FEEDLOT PADS

The estimation of odour emission rates from cattle feedlots is a contentious issue and has been the subject of intensive investigation over the past ten years. A wide range of emission rates can be found in the literature varying by as much as two orders of magnitude.

**Table 2** summarises emission rates which have been measured from pen surfaces at Australian feedlot.

**Table 2. Measurements of odour emissions from pen surfaces at Australian feedlots.**

| Location | Emission rate (OU m/s) | Sampling method | Pad moisture content (% db) | Source |
|---|---|---|---|---|
| Peechelba, Vic | 0.11 | Flux hood | N/A | Ross 1989 |
| Cannon Hill, Qld | 0.5 to 2.0 | Flux hood | 35 to 85 | Carson & Round 1990 |
| Kerwee, Qld | 13 to 700 | Wind tunnel | 35 to 183 | Watts 1992 |
| Yanco, NSW | 5 to 21 | Wind tunnel | Dry to moist | Freeman 1992 |

Determining which of these to use in dispersion modelling has proven to be a difficult task.

It is useful to summarise the approaches that have been adopted in dispersion modelling and how emission rates determined from different measurement methodologies have been applied.

## *4.1 Odour emission rates using isolation flux hood*

The earliest odour emission rates measured from cattle feedlots were taken directly from the feedlot pad and were made using what is referred to as an isolation flux hood. Odour measurements with this methodology are generally in the range of 0.1 to 2.0 $ou/m^2/sec$ (Ross, Carson & Round). Emission rates were found to depend on temperature and the moisture content of the feedlot pad which in turn was related to recent rainfall events. The way in which the feedlot was maintained, that is the depth of the feedlot pad and its moisture content as well as cattle stocking density, was an important factor.

The QDPI Guidelines were based on odour modelling using these type of emission rates. Subsequent comparison of these emission rates with other emission rate methodologies indicates that the isolation flux hood method is likely to represent odour emission rates under very calm atmospheric conditions. It is under these atmospheric conditions that maximum impacts have been observed to occur in the far field where odour is transported significant distances off-site. In the near field odour impacts can occur under other atmospheric conditions where the emission rate may be far greater. These odour emission rates have been used in odour assessments for several cattle feedlots including the feedlot at Kabinga (**Hassall & Associates, 1989**) and at Mungeribar (**Nigel Holmes & Associates, 1991**) and compared with odour goals similar to those described in the Guidelines.

### *4.2 Odour emission rates using wind tunnels*

More recently wind tunnels have been used to measure odour emission rates from feedlot pads. This methodology differs from the isolation flux hood primarily in the rate at which air is drawn across the surface of the feedlot pad. Odour measurements with this technology can be 2 orders of magnitude greater than the measurements obtained using the isolation flux chamber method (**Watts, 1992**).

The reasons for the large apparent discrepancies between the measurement methodologies is likely to reflect the fact that the measurements relate to emissions under different atmospheric conditions. Rather than being contradictory it is likely that these measurements are complimentary. As discussed above, measurements made using isolation flux hood chambers may represent emissions under very calm inversion conditions whereas measurements made with wind tunnels may represent measurements made under windy conditions or conditions of high solar radiation where the atmosphere has good dispersive capacity.

If the measurements made with the wind tunnel technique are used in dispersion modelling without taking these factors into account, the predicted odour levels are very high under calm atmospheric conditions. It is likely that some factoring of emissions, wind speed and stability class is required to provide a more realistic estimate of off-site emissions.

### *4.3 Odour emission rates from back calculations*

In addition to direct measurements of emissions from feedlot surfaces a method of back calculating based on ambient measurements has also been developed (**Smith & Kelly, 1995**). The back calculation method has some advantages over area source measurement. Firstly, it removes the heterogeneity factor involved with sampling from a large source such as a feedlot, that is, which part of the surface should be sampled. Secondly, it removes the compounding factor of how surface measurements relate to different meteorological conditions because the back calculation is done under known meteorological conditions.

Most of the measurements reported however were made under either neutral atmospheric or unstable conditions, that is daytime conditions, whereas most of the observed impacts from cattle feedlots occur during stable conditions such as occur early morning or late afternoon or during the evening.

Some extensive measurements were made under just such conditions at a feedlot in NSW (**Dean & Freeman, 1994**). With this technique there was reasonable agreement between the lower emission rates determined by the ambient sampling method by **Smith & Kelly (1995)**.

## 5 FACTORS AFFECTING EMISSIONS FROM CATTLE FEEDLOT PADS

The main source of odour on a cattle feedlot is from the manure pads in the pens, where decomposition can occur either by anaerobic or aerobic pathways. In general the aerobic processes tend to produce little odour but slower and less complete anaerobic decomposition digestion has more complex by-products which tend to be more odorous. After rainfall, anaerobic conditions tend to prevail.

The factors which affect odour emissions are therefore predominantly temperature and moisture content, the latter being a function of the rainfall, feedlot management and stocking density.

Most of the assessments which have been undertaken with the feedlots have assumed a constant emission rate. This is clearly an oversimplification and to further refine the process of estimating feedlot emissions a model has been developed as part of the Meat Research Corporation Project DAQ.079. The findings of this were reported in Milestone Report No. 14 entitled "Development of a Model to Predict the Rate of Odour Emissions from Cattle Feedlots" (**Lunney and Smith, 1994**).

This emission model is not yet publicly available for use in dispersion modelling although the basic equations have been presented in the Milestone Report No. 14. The validation of these equations are based on seven trials which took place in Queensland feedlots. The model was found to explain 64% of the variations for all of the trials over the 4 year period.

In summary, the emission rate is a function of stocking density, moisture content, temperature of the pad and a function of the number of days since rainfall and the time to peak after rain. The following equation was fitted to all the experiments.

$$E_1 = \alpha \delta^{1.8} \theta^{0.77 T_P^{0.13}} F(\theta, T_a)$$

where:

$\alpha$ = a constant
$\delta$ = weight in kg per $m^2$ of beast
$\theta$ = a measure of moist content of the pad in percent
$T_P$ = pad temperature
$F$ = function based on time after a rainfall event

This equation can be applied to continuous meteorological data provided all the information is available. In the case of the feedlots studied in this report there was insufficient information available from all feedlots to use this equation. Further, the program which links the variable emission rates to AUSPLUME is not yet in the public domain.

Nevertheless, this basic equation was drawn upon to provide some estimate of the variation in emissions at the different feedlots on a monthly basis. Account was taken of the historical rainfall and temperature data for the area as well as the stocking density at the individual feedlots. However it must be noted that some assumptions were made which cannot be regarded as rigorous.

It was assumed that average monthly rainfall would be correlated to pad moisture content. This is clearly an oversimplification as rainfall is not constant over that period and all evidence suggests that emission tend to peak after a period of heavy rainfall. Further, it was also assumed that average monthly temperature would act as a surrogate for pad temperature. Again, this is a significant oversimplification as there will be considerable diurnal variation in pad temperature as well as pad heat generated by the microbial activity.

However, given the lack of availability of the final version of the emissions model in the public domain, this approach has been adopted to provide a distinction between the different feedlots considered in this report based on stocking density, average temperatures and rainfall.

The approach has used measured emission rates at the Yanco Feedlot in NSW undertaken by Freeman (**Dean & Freeman, 1994**) in 1993. This was based on extensive field measurements where ambient odour levels were measured under calm, stable atmospheric conditions and back calculations with dispersion modelling used to determine emission rates.

Odour emission rates under E or F class stability range from 5.9 to 30.4 odour units.$m^3/m^2/s$ where odour was reported in detection units with an average of 15.5 for twelve tests. The average ambient temperature during these measurements was 9.6 C Measurements were made predominantly in May and June. The cattle feedlot in question had a stocking density of approximately 16 $m^2$/head and it was assumed that the average moisture content of the pad was 100%. This related to an average rainfall of 54 mm.

Using the feedlot emission equation and fitting this average emission rate to this temperature and moisture content and stocking density, an $\alpha$ value of 1.5 was determined.

This equation was then applied to all the feedlots considered in this report taking account of average rainfall and temperature conditions as well as the stocking density of the feedlot. Average monthly emission rates were then calculated. The odour emission rates were then adjusted to odour certainty units by dividing by 3. This relationship between odour detection and odour certainty/recognition was determined from the 74 samples collected at the Yanco feedlot.

Details of the way in which the monthly emission from the feedlots were calculated is provided in **Appendix A**.

## 6 FEEDLOTS CONSIDERED IN THIS STUDY

This section summarises the information from the five feedlots considered in this study. **Table 3** provides information on general location, class of feedlot, stocking density, feedlot numbers and other relevant factors.

**Table 3. Summary of general information for five feedlots considered in this study.**

| | Location | No. of Standard Cattle Units (SCU) | Stocking density (beast/$m^2$) | Annual rainfall | Class of Feedlot |
|---|---|---|---|---|---|
| Feedlot A | Queensland | 11,000 | 19 | below 750 mm | 2 |
| Feedlot B | Queensland | 18,000 | 15 | below 750 mm | 1 |
| Feedlot C | Queensland | 15,000 | 12 | below 750 mm | 2 |
| Feedlot D | NSW | 20,000 | 18 | below 750 mm | 2 |
| Feedlot E | NSW | 23,000 | 14 | below 750 mm | 2 |

Site-specific meteorological data were available for all the feedlots and have been processed into a form suitable for dispersion modelling. Windroses prepared from these data are shown in **Figures 1-5**. The windroses show the general pattern of winds in the area, and are particularly useful for determining lines of drainage flow.

**Table 4** presents the monthly emission rates calculated for the feedlots considered in this report. It can be seen that the range of emission rates do not cover the full range of emission rates reported by the measurements made in the Queensland feedlots. However it is considered that the higher measurements may represent emissions into a neutral to unstable atmosphere, that is better dispersion conditions. If these emission rates are then coupled in the modelling with poor dispersion conditions they may result in an over-estimate of impacts under calm atmospheric conditions.

**Table 4: Estimated monthly emission rates from Feedlots considered in this study**

**(ou.m³/m²/s)**

| | Feedlot A | Feedlot B | Feedlot C | Feedlot D | Feedlot E |
|---|---|---|---|---|---|
| Jan | 10.8 | 17.6 | 32.1 | 8.1 | 19.0 |
| Feb | 11.5 | 15.4 | 22.8 | 7.3 | 13.5 |
| Mar | 6.2 | 12.7 | 17.7 | 6.4 | 11.0 |
| Apr | 3.6 | 5.7 | 8.6 | 4.9 | 7.0 |
| May | 3.8 | 4.7 | 7.9 | 3.3 | 5.8 |
| Jun | 2.5 | 4.7 | 7.0 | 2.5 | 5.6 |
| Jul | 2.5 | 4.5 | 6.6 | 2.3 | 4.8 |
| Aug | 2.2 | 3.6 | 5.4 | 2.5 | 5.3 |
| Sep | 3.0 | 5.6 | 6.9 | 2.8 | 6.8 |
| Oct | 6.6 | 12.9 | 14.0 | 5.2 | 11.0 |
| Nov | 10.4 | 14.4 | 19.6 | 5.4 | 12.4 |
| Dec | 13.8 | 19.7 | 28.9 | 4.6 | 17.1 |

In addition to these variable emission rates, a constant emission rate was also used. This rate was assumed to be 5 odour units.$m^3/m^2/s$, the average of the emission rates (expressed as certainty units) calculated at Yanco. These emission rates take no account of local temperature or rainfall conditions.

## 7 RESULTS OF DISPERSION MODELLING

This section presents the results of dispersion modelling for the five feedlots and compares the results with the separation distances calculated using the Guidelines. The results of the modelling are presented as contour plots for all of the feedlots with both variable emission rates and constant emission rates. Predicted odour levels at the 99.9, 99.5 and 99$^{th}$ percentile level are presented.

The dispersion model AUSPLUME (**VEPA. 1986**) was used in conjunction with on-site meteorological data to predict hourly average odour levels at receptors in the vicinity of the feedlots. Odour sources were assigned according to the feedlot layout and were based on the stocking density and number of SCU.

**Table 5** presents a summary of separation distances calculated according to the QDPI Guidelines for farmhouse receptors based on flat terrain and drainage flows with the maximum S3 factor of 2. (We note that in the revised Guidelines there is provision for variation in this factor from a value of 1.2 to 2). These distances are compared with the extent of the 20 odour unit contour at the 99.5 and 99th percentile level and the 10 odour unit contour at the 99$^{th}$ percentile.

These contours do not extend to an equal distance in all directions from the feedlot. Therefore the (approximate) maximum and (approximate) average extent has been considered to represent respectively the predominant line of drainage flows and essentially flat terrain

All distances are from the centre of the odour source.

The best agreement between the QDPI distances and those predicted by dispersion modelling are for the constant emission rates and the 20 odour units at the 99% compliance level. These have been shaded in **Table 5**. Feedlot B shows the worst agreement. This is the only Class 1 feedlot according to the Guidelines and this has not been allowed for in the dispersion modelling. All the other feedlots are Class 2 as was the Yanco feedlot. Therefore it would be appropriate to add another factor to reduce the emission rates to take account of this.

It is perhaps not surprising that there is a better agreement with the constant emission rates as the original guidelines were also drawn from dispersion modelling using constant emission rates. Nevertheless, in some instances, there is quite good agreement between the Guidelines and modelling where variable emission rates were assumed.

There are, as discussed, many factors which influence emission rates and there are not always sufficient data to accurately represent what is happening in real life. It is considered that the constant emission rate scenario is reasonably representative of emissions under the most stable atmospheric conditions. As discussed in **Section 4.3**, these are based on measurements made at cattle feedlots using back calculations from dispersion modelling, therefore there is a degree of self consistency in these data. There will be throughout the day and at different times of year, emission rates which are substantially higher than those used in the modelling, however in many instances these will be off-set by better dispersion conditions.

The separation distances measured by the Guidelines are in reasonable agreement with dispersion modelling results if the 20 odour unit 99 percentile goal is used. This is a high goal compared to those being considered by regulatory authorities for other agricultural activities. However, given the nature of odour from well-managed feedlots, this may not be unreasonable. Poorly managed feedlots with a high degree of anaerobic activity in the pad are likely to have more offensive odours.

It is interesting to note that the drainage factor S3 provides a surrogate for the frequency factor supplied by on-site meteorological data. Low speed winds under stable condition will follow the drainage flows. This will result in the most frequent odour Imax and the frequency contours will extend out the furthest in that direction. Therefore the drainage factor S3 mimics to some extent the frequency plots. On-site meteorological data however must provide a better overall picture of the pattern of dispersion and the extent of the impact.

**Table 5. Summary of separation distances/impact distances for five feedlots considered in this study based on QDPI equation and dispersion modelling. (metres)**

| QDPI | | | Modelling | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Variable emissions | | | | | | Constant emissions | | | | | |
| | Flat | Drainage | Flat | | | Drainage | | | Flat | | | Drainage | | |
| | | | 20 ou 99.5% | 20 ou 99% | 10 ou 99% | 20 ou 99.5% | 20 ou 99% | 10 ou 99% | 20 ou 99.5% | 20 ou 99% | 10 ou 99% | 20 ou 99.5% | 20 ou 99% | 10 ou 99% |
| Feedlot A | 1640 | 3280 | 1870 | 1250 | 1870 | 3750 | 3000 | 4375 | 1870 | 1500 | 1870 | 3750 | 3125 | 4375 |
| Feedlot B | 1883 | 3767 | 5000 | 4125 | 5000 | >12,000 | >12000 | >12000 | 4375 | 3125 | 4375 | 9000 | 6875 | 12000 |
| Feedlot C | 2910 | 5820 | 7000 | 3700 | 7000 | >12000 | >12000 | >12000 | 4375 | 3125 | 5000 | 5600 | 5625 | 8000 |
| Feedlot D | 2520 | 5040 | 2500 | 1875 | 2500 | 5200 | 4000 | 6700 | 3125 | 2250 | 3375 | 5250 | 4000 | 6375 |
| Feedlot E | 3316 | 6630 | 8400 | 4375 | 8700 | 12000 | >12000 | >12000 | 7200 | 3750 | 7000 | 9375 | 7200 | >12000 |

## 8 CONCLUSIONS

This report has revisited the QDPI Guidelines for separation distances for cattle feedlots and has compared these with the results of dispersion modelling using on-site meteorological data for five cattle feedlots in Queensland and NSW. The results of the study are as follows.

- The separation distances calculated using the Guidelines are consistent with odour goals based on dispersion modelling of 20 odour units at the 99% compliance level.
- These model predictions are based on constant emission rates which are representative of well managed feedlot under worst-case dispersion conditions.
- While these goals are somewhat higher than those set by other regulatory authorities they may not be unreasonable given the *relatively* inoffensive nature of the odour from a well managed feedlot.

The following conclusions are drawn from these findings.

- QDPI Guidelines provide a reasonable "ball park" estimate for defining an impact area.
- If site specific meteorological data are available, that are likely to better define the area of impacts and they should be used in preference to the Guidelines.
- Once the emissions model is publicly available this should be used to help refine appropriate odour goals for this industry. The model should be provided with guidance for use.
- It is considered that the odour impact level is likely to be somewhere between 10 and 20 odour units at somewhere between the 99.5 to 99th percentile.

minimum 20 ou at 99%tile.

QDPI considers that the goals are reasonable because over the last 10 years they have worked. In response, the feedlot industry considers that this is due in part of better management of the feedlots and this is likely to be the case. In addition the weather up until 1995 has been reasonably dry. A study by **Skerman and others** in 1995 indicated that during the very wet conditions in 1995/1996 in Queensland there were significantly more odour complaints. The reasons for this have not been conclusively determined. According to this article a contributing factor may have been the publication of an advertisement advising readers to complain to DPI if they detected an odour. However the inability of retention ponds to cope with additional load is likely to be a significant factor.

In conclusion, as a "Tier 1" approach the Guidelines appear reasonable, although they obviously do not encompass site-specific factors as well as dispersion modelling with on-site meteorological data. They are likely however to provide useful guidance for a small operation where collection of meteorological data may prove onerous. Larger operations, as is the common practice, are likely to provide themselves with better information better by collecting site-specific data.

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## APPENDIX A
## EMISSION CALCULATION FOR THE FIVE FEEDLOTS

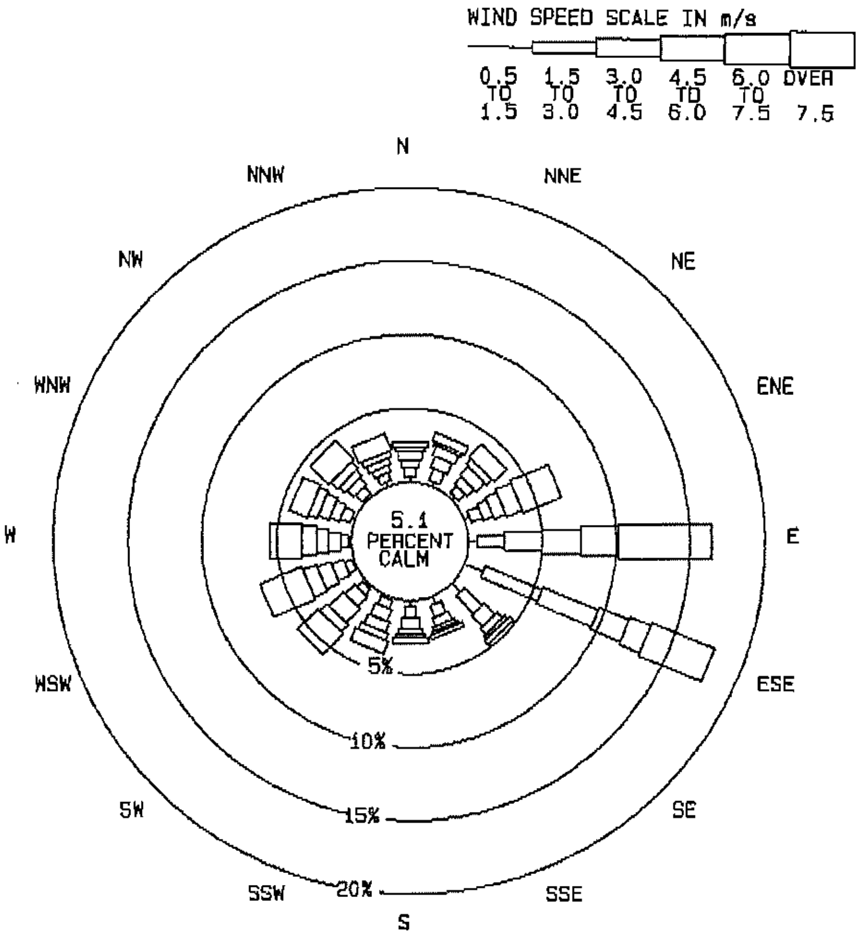
| Yanco | | | | | |
|---|---|---|---|---|---|
| Month | Temperature C | Rainfall mm | Moisture (%) | Weight/m2 | Odour emissions OU/m2/s |
| Jan | 22.7 | 43 | 86 | 41 | 6.9 |
| Feb | 22 | 38 | 76 | 41 | 5.8 |
| Mar | 19.5 | 43 | 86 | 41 | 6.2 |
| Apr | 14.3 | 44 | 88 | 41 | 5.2 |
| May | 9.7 | 54 | 108 | 41 | 5.1 |
| Jun | 6.6 | 45 | 90 | 41 | 3.4 |
| Jul | 5.5 | 54 | 108 | 41 | 3.6 |
| Aug | 7.6 | 54 | 108 | 41 | 4.4 |
| SEP | 10.6 | 50 | 100 | 41 | 5.0 |
| Oct | 14.8 | 61 | 122 | 41 | 7.6 |
| Nov | 18 | 43 | 86 | 41 | 5.9 |
| Dec | 21.3 | 41 | 82 | 41 | 6.2 |
| Feedlot A | | | | | |
| Month | Temperature C | Rainfall mm | Moisture (%) | Weight/m2 | Odour emissions OU/m2/s |
| Jan | 24 | 82 | 164 | 34 | 10.8 |
| Feb | 23.4 | 88 | 176 | 34 | 11.5 |
| Mar | 22 | 54 | 108 | 34 | 6.2 |
| Apr | 19 | 36 | 72 | 34 | 3.6 |
| May | 14.8 | 44 | 88 | 34 | 3.8 |
| Jun | 10.2 | 36 | 72 | 34 | 2.5 |
| Jul | 9.7 | 38 | 76 | 34 | 2.5 |
| Aug | 11.8 | 30 | 60 | 34 | 2.2 |
| SEP | 16 | 34 | 68 | 34 | 3.0 |
| Oct | 19.1 | 62 | 124 | 34 | 6.6 |
| Nov | 22 | 84 | 168 | 34 | 10.4 |
| Dec | 24 | 101 | 202 | 34 | 13.8 |
| Feedlot B | | | | | |
| Month | Temperature C | Rainfall mm | Moisture (%) | Weight/m2 | Odour emissions OU/m2/s |
| Jan | 25.1 | 84 | 168 | 43 | 17.6 |
| Feb | 24.7 | 76 | 152 | 43 | 15.4 |
| Mar | 23.2 | 67 | 134 | 43 | 12.7 |
| Apr | 20.2 | 36 | 72 | 43 | 5.7 |
| May | 15.5 | 35 | 70 | 43 | 4.7 |
| Jun | 11.7 | 41 | 82 | 43 | 4.7 |
| Jul | 10.5 | 42 | 84 | 43 | 4.5 |
| Aug | 13 | 30 | 60 | 43 | 3.6 |
| SEP | 17 | 39 | 78 | 43 | 5.6 |
| Oct | 30.7 | 57 | 114 | 43 | 12.9 |
| Nov | 23.5 | 74 | 148 | 43 | 14.4 |
| Dec | 25 | 93 | 186 | 43 | 19.7 |

| | | | | | |
|---|---|---|---|---|---|
| | | | Feedlot C | | |
| Month | Temperature C | Rainfall mm | Moisture (%) | Weight/m2 | Odour emissions OU/m2/s |
| Jan | 25.5 | 98 | 196 | 54 | 32.1 |
| Feb | 25.1 | 74 | 148 | 54 | 22.8 |
| Mar | 23.5 | 62 | 124 | 54 | 17.7 |
| Apr | 20.5 | 36 | 72 | 54 | 8.6 |
| May | 15.6 | 39 | 78 | 54 | 7.9 |
| Jun | 11.6 | 41 | 82 | 54 | 7.0 |
| Jul | 10.6 | 41 | 82 | 54 | 6.6 |
| Aug | 13.4 | 30 | 60 | 54 | 5.4 |
| SEP | 17.6 | 32 | 64 | 54 | 6.9 |
| Oct | 21.1 | 54 | 108 | 54 | 14.0 |
| Nov | 24.0 | 67 | 134 | 54 | 19.6 |
| Dec | 25.4 | 90 | 180 | 54 | 28.9 |

| | | | | | |
|---|---|---|---|---|---|
| Month | | | Feedlot D | | |
| | Temperature C | Rainfall mm | Moisture (%) | Weight/m2 | Odour emissions OU/m2/s |
| Jan | 24.4 | 58 | 116 | 36 | 8.1 |
| Feb | 23.5 | 54 | 108 | 36 | 7.3 |
| Mar | 22.2 | 50 | 100 | 36 | 6.4 |
| Apr | 27.9 | 35 | 70 | 36 | 4.9 |
| May | 13.5 | 37 | 74 | 36 | 3.3 |
| Jun | 9.3 | 35 | 70 | 36 | 2.5 |
| Jul | 8.5 | 34 | 68 | 36 | 2.3 |
| Aug | 10.7 | 32 | 64 | 36 | 2.5 |
| SEP | 14.2 | 31 | 62 | 36 | 2.8 |
| Oct | 18.7 | 46 | 92 | 36 | 5.2 |
| Nov | 20.7 | 45 | 90 | 36 | 5.4 |
| Dec | 24 | 36 | 72 | 36 | 4.6 |

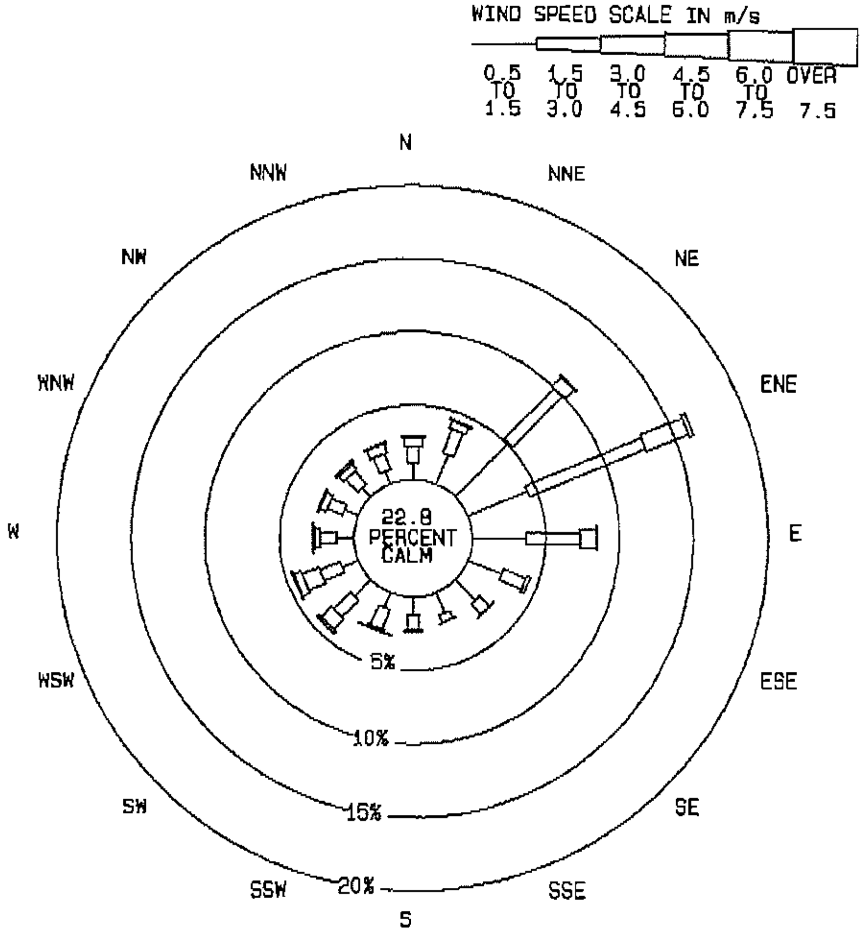
| | | | | | |
|---|---|---|---|---|---|
| | | | Feedlot E | | |
| | Temperature C | Rainfall mm | Moisture (%) | Weight/m2 | Odour emissions OU/m2/s |
| Jan | 23.8 | 84 | 168 | 46 | 19.0 |
| Feb | 22.9 | 64 | 128 | 46 | 13.5 |
| Mar | 22 | 55 | 110 | 46 | 11.0 |
| Apr | 17.9 | 42 | 84 | 46 | 7.0 |
| May | 12.6 | 43 | 86 | 46 | 5.8 |
| Jun | 8.7 | 52 | 104 | 46 | 5.6 |
| Jul | 7.6 | 48 | 96 | 46 | 4.8 |
| Aug | 10 | 45 | 90 | 46 | 5.3 |
| SEP | 14.4 | 46 | 92 | 46 | 6.8 |
| Oct | 19 | 60 | 120 | 46 | 11.0 |
| Nov | 20.9 | 63 | 126 | 46 | 12.4 |
| Dec | 23.2 | 78 | 156 | 46 | 17.1 |

## FIGURES



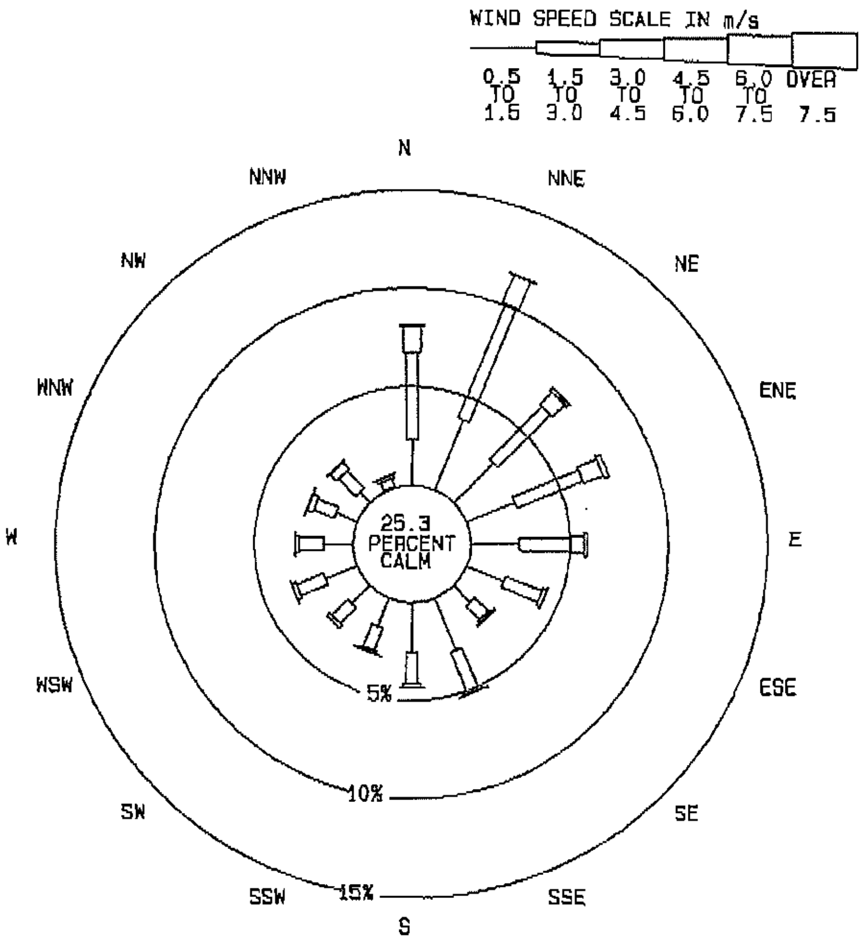

DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Windrose for Feedlot A

**FIGURE 1**



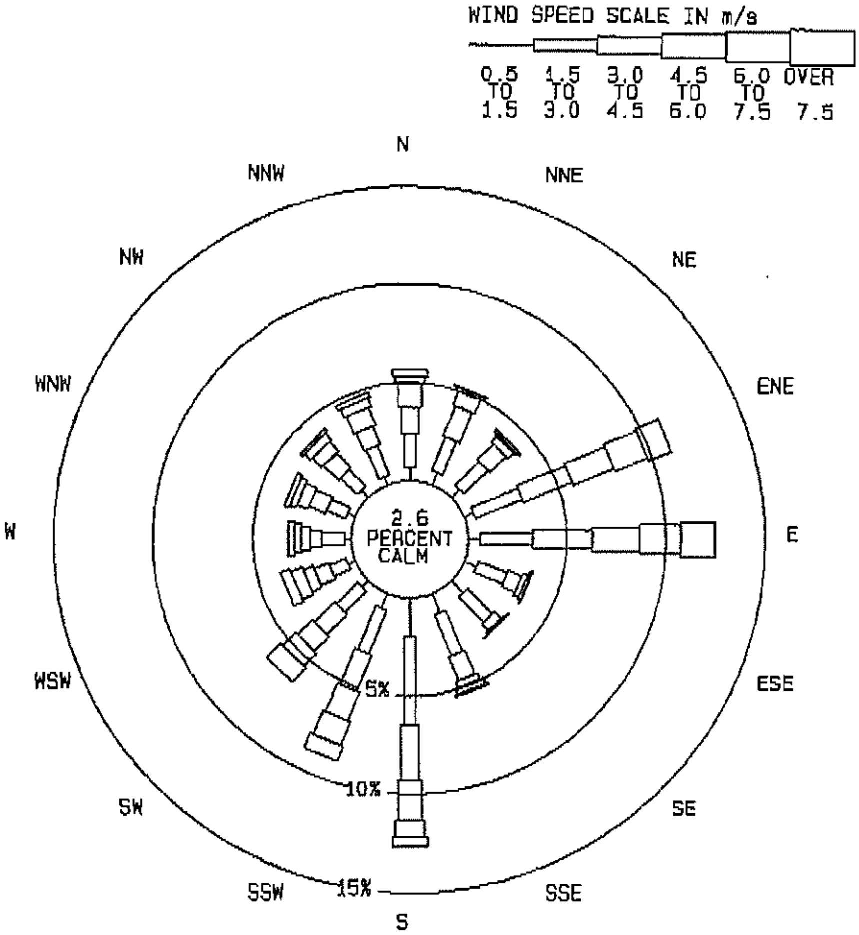

DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Windrose for Feedlot B

**FIGURE 2**



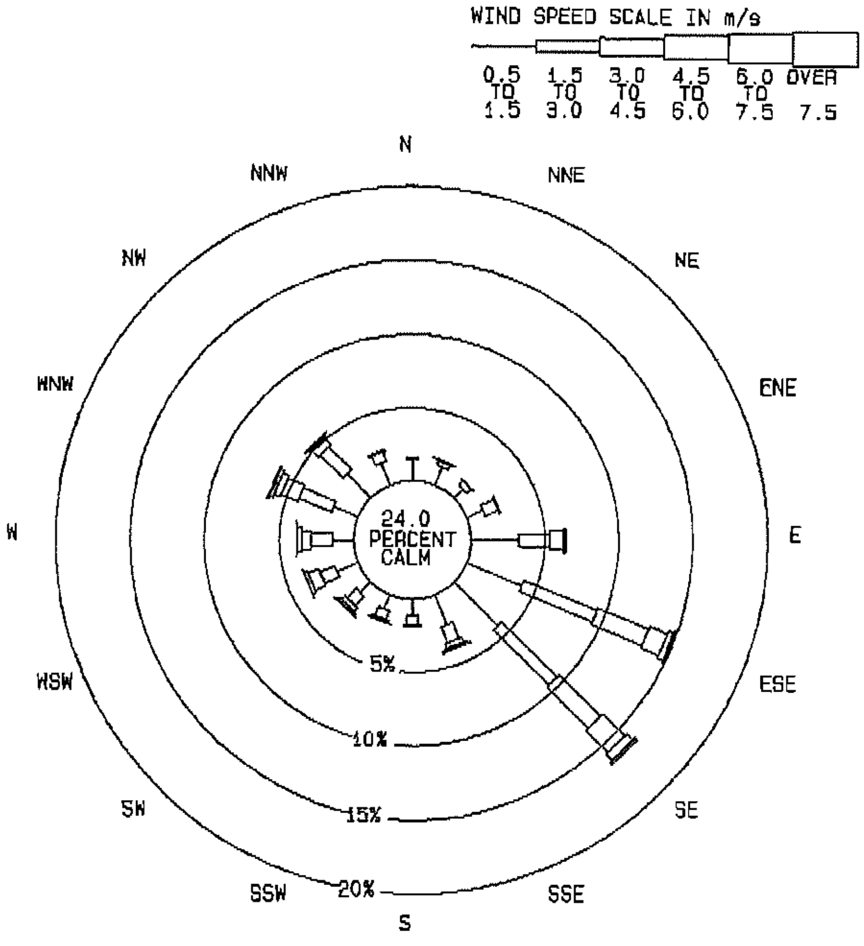

DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Windrose for Feedlot C

**FIGURE 3**



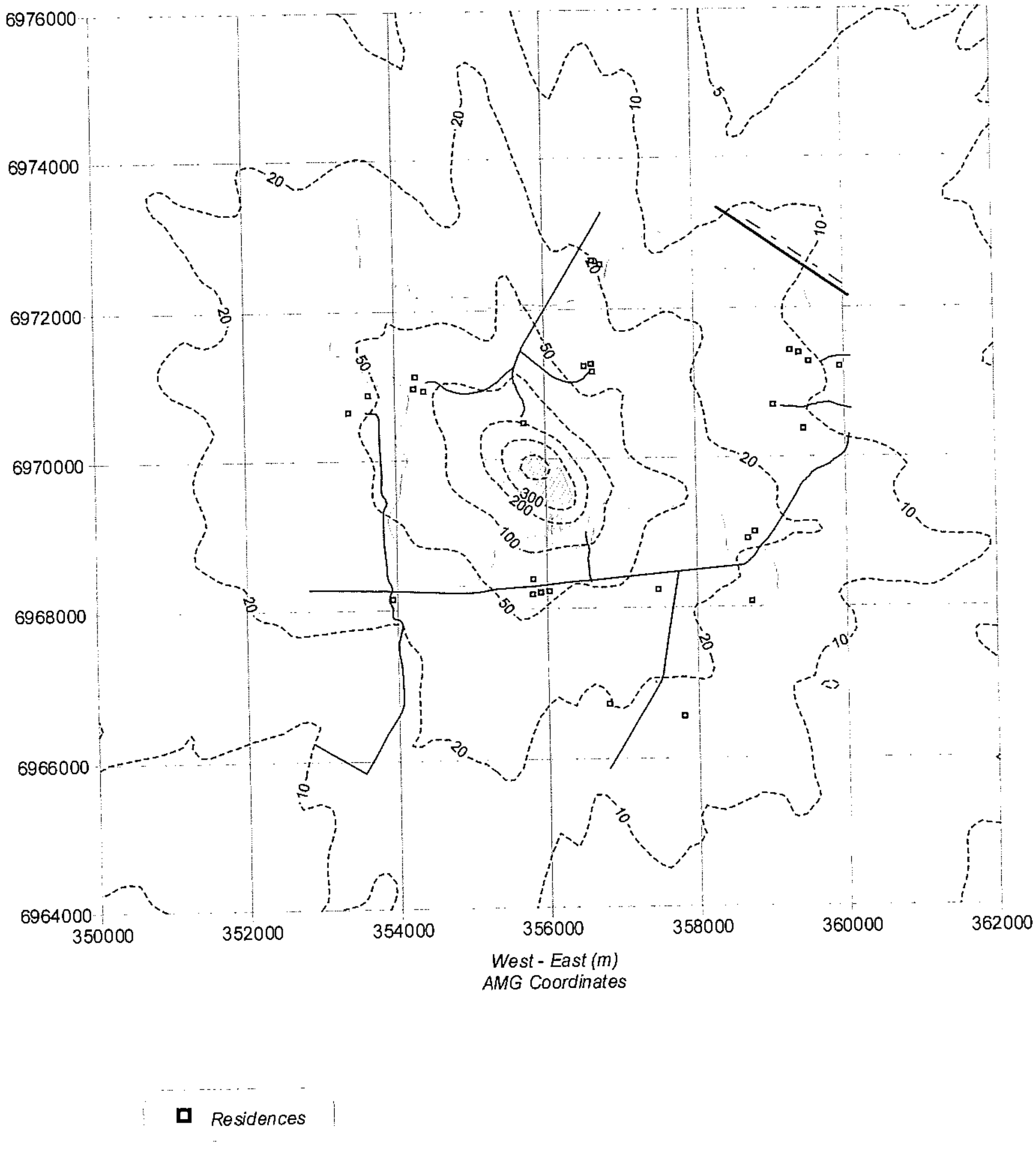

DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Windrose for Feedlot D

FIGURE 4



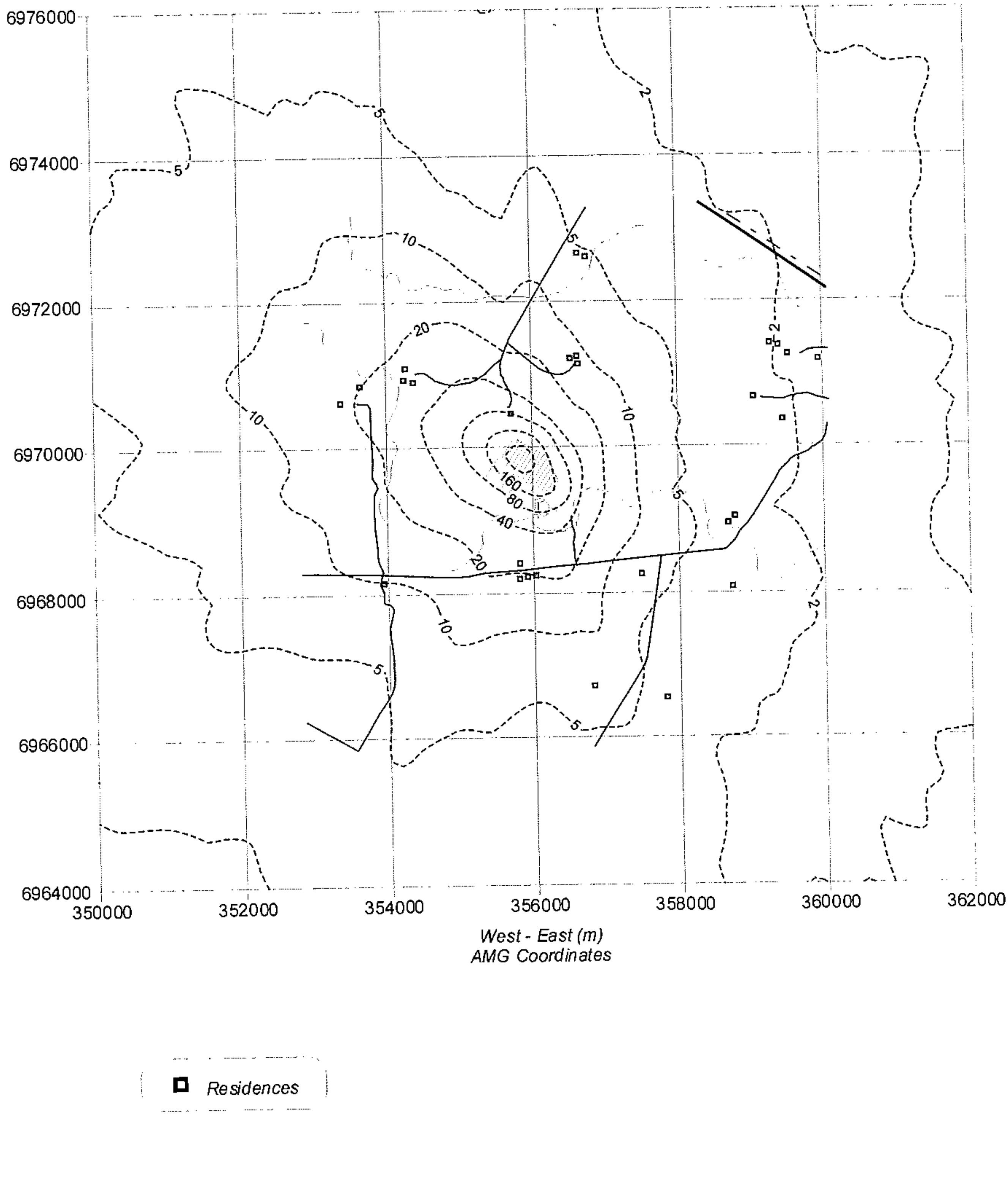

DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Windrose for Feedlot E

**FIGURE 5**



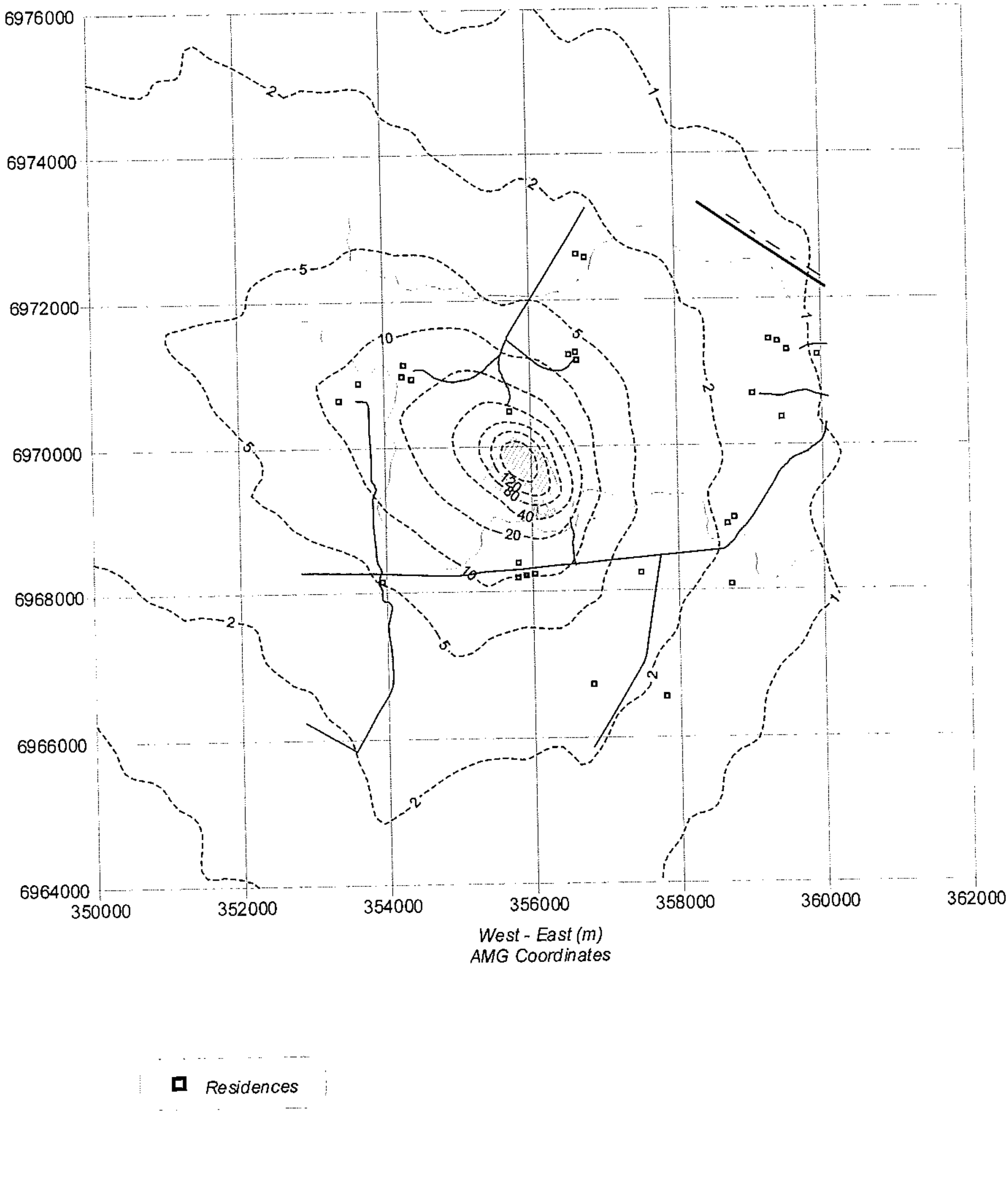

**Predicted 99.9 percentile compliance odour levels, variable emission rate (odour units) - Feedlot A**

**FIGURE 6**



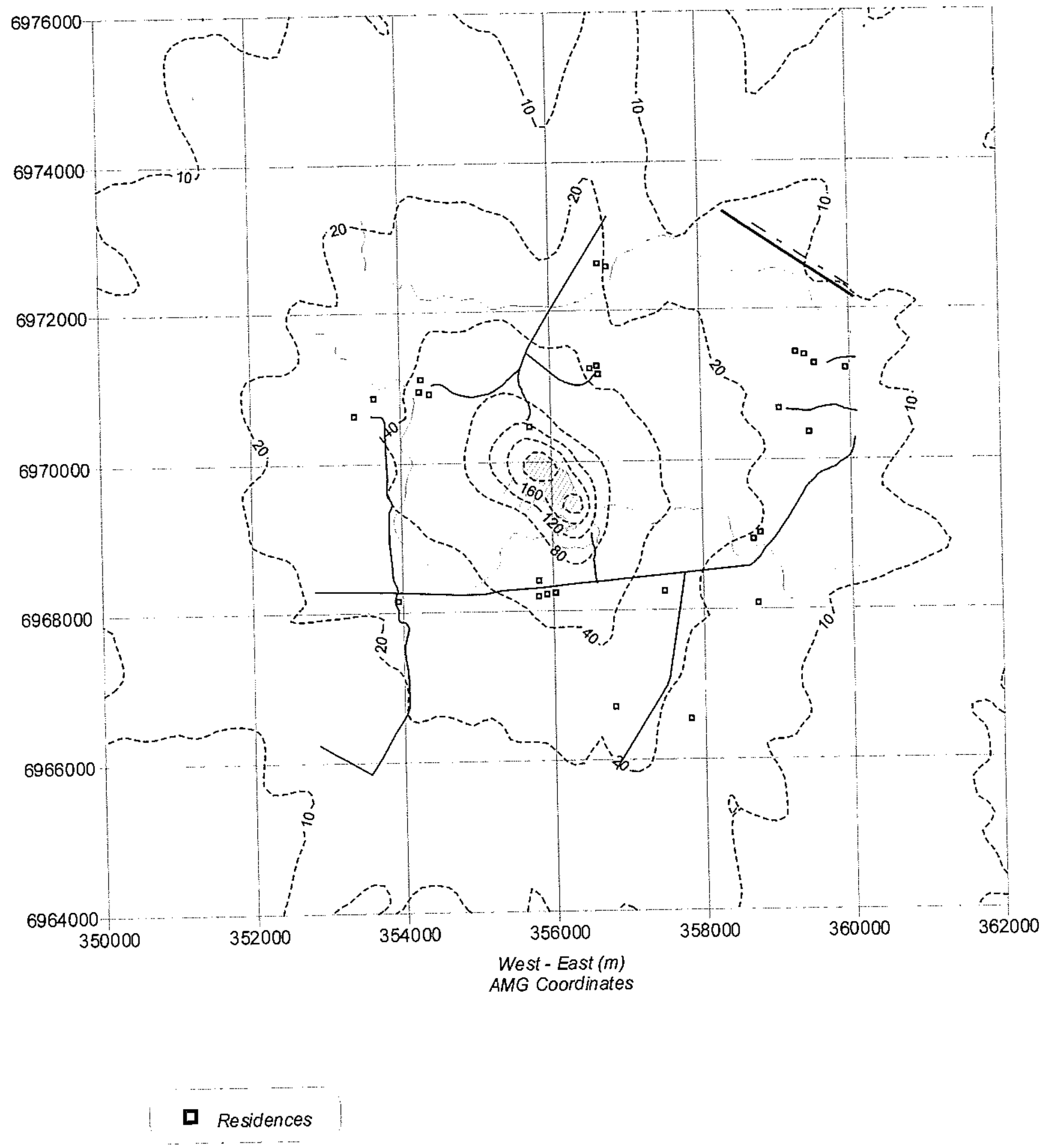

**Predicted 99.5 percentile compliance odour levels, variable emission rate (odour units) - Feedlot A**

**FIGURE 7**



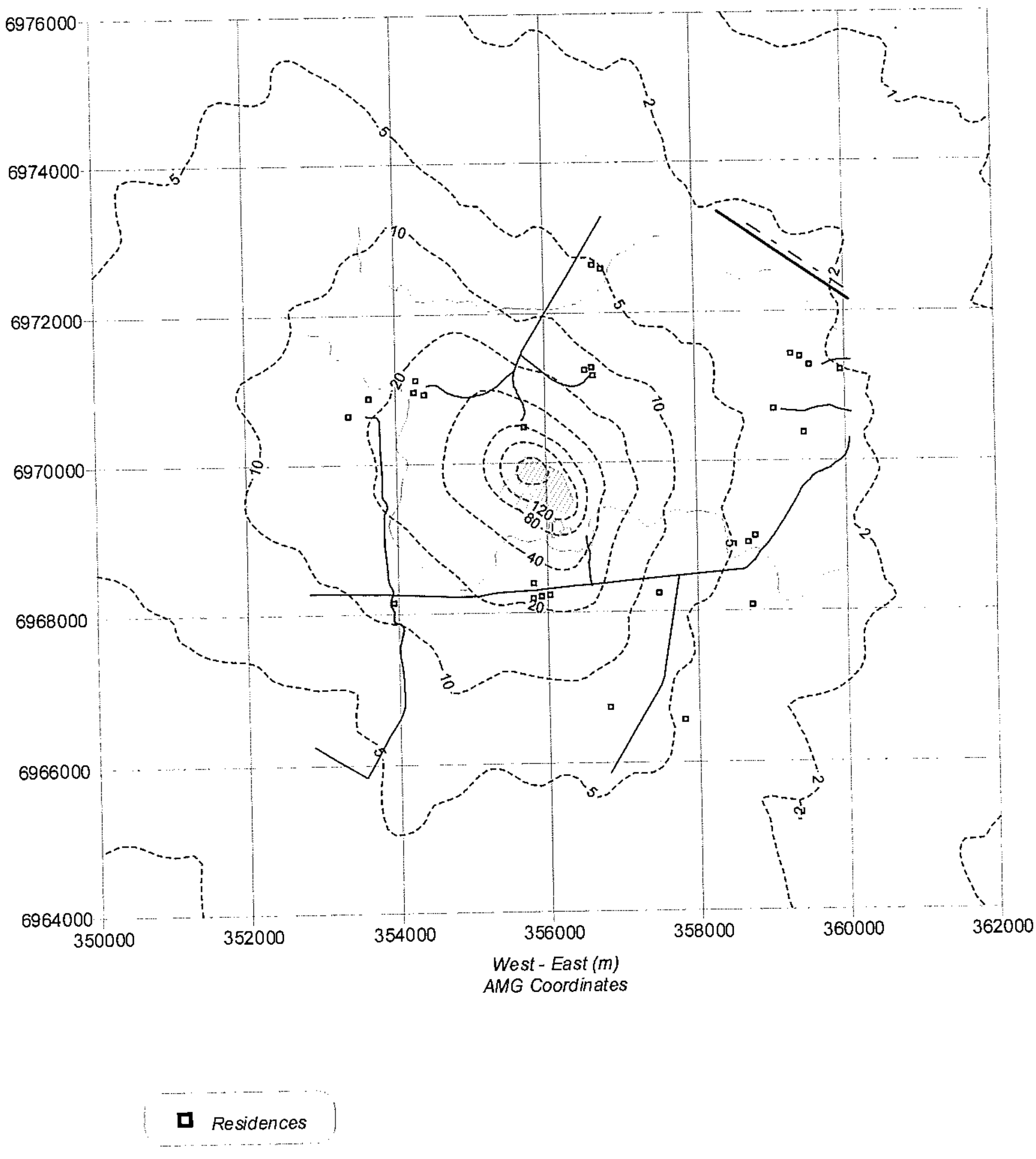

**Predicted 99th percentile compliance odour levels, variable emission rate (odour units) - Feedlot A**

**FIGURE 8**



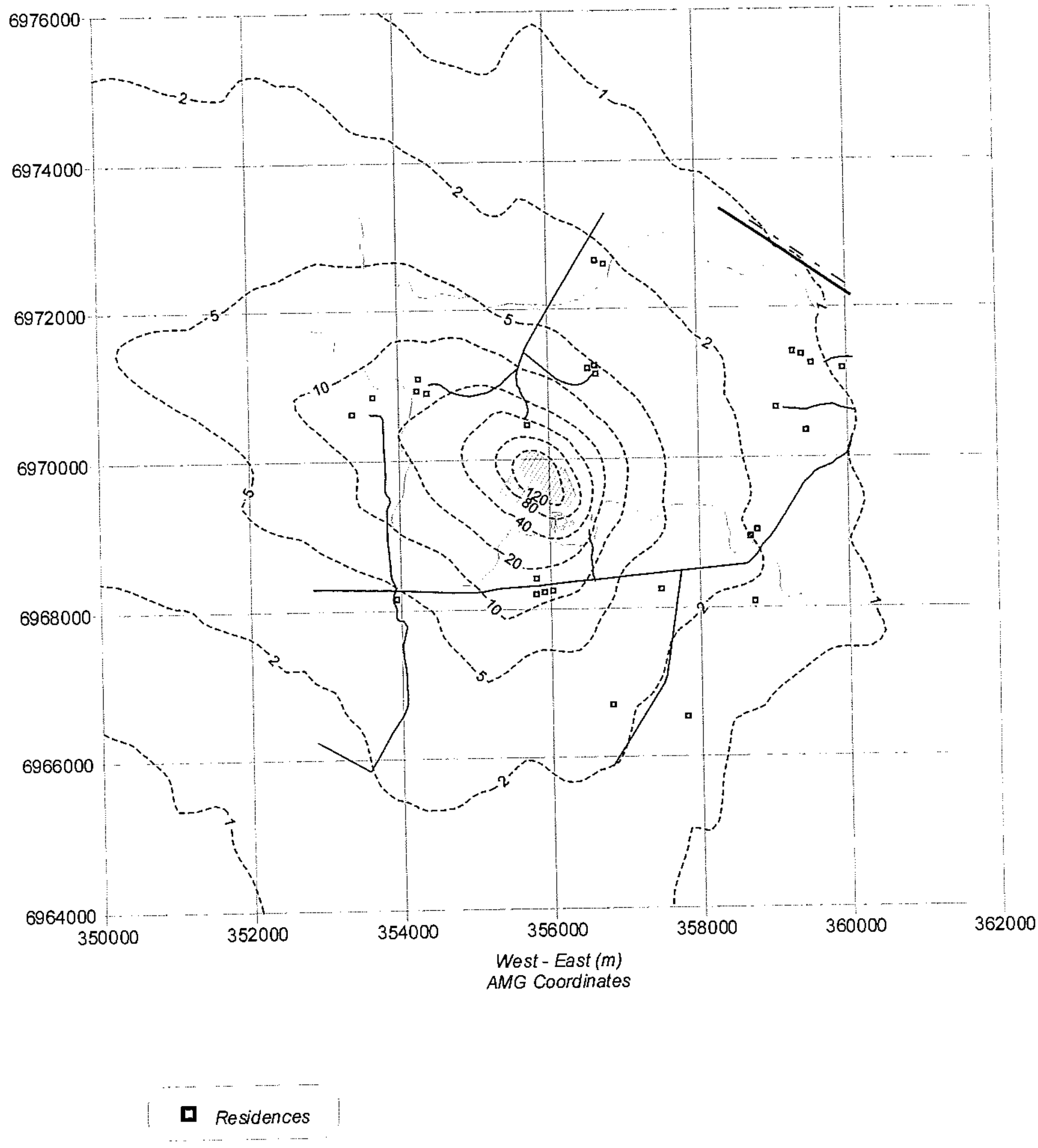

**Predicted 99.9 percentile compliance odour levels, constant emission rate (odour units) - Feedlot A**

**FIGURE 9**



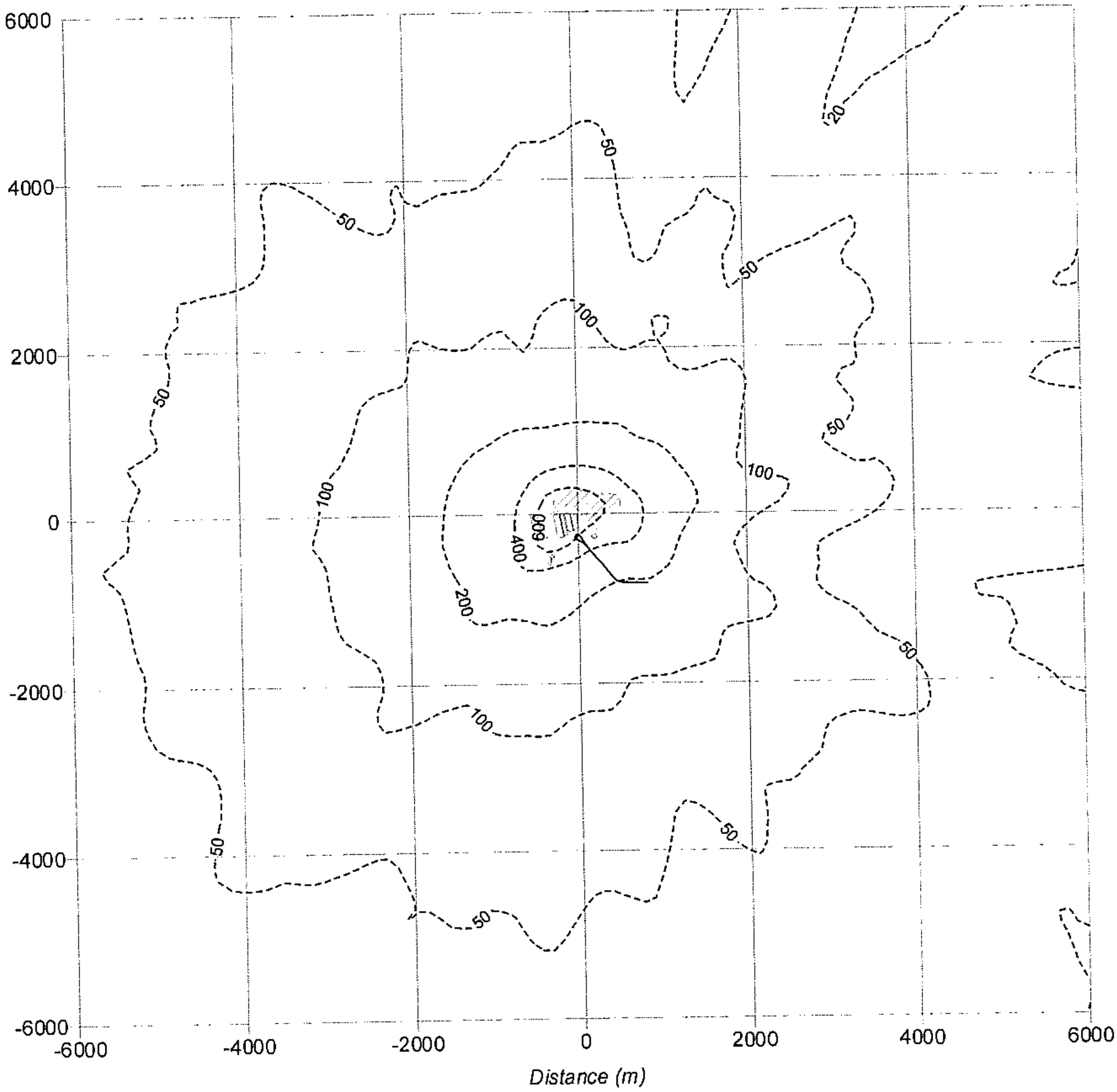

**Predicted 99.5 percentile compliance odour levels, constant emission rate (odour units) - Feedlot A**

**FIGURE 10**



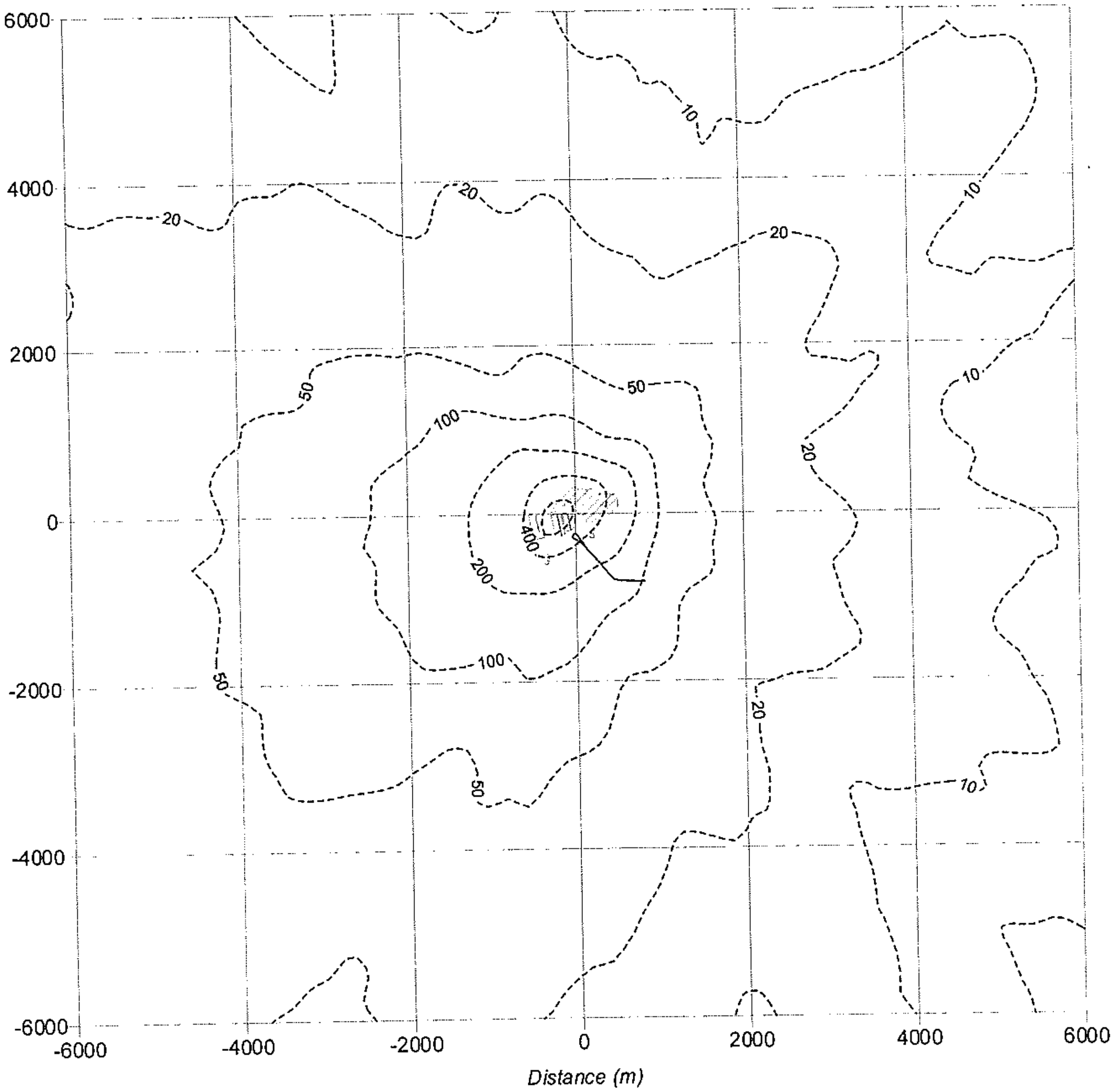

**Predicted 99th percentile compliance odour levels, constant emission rate (odour units) - Feedlot A**

**FIGURE 11**



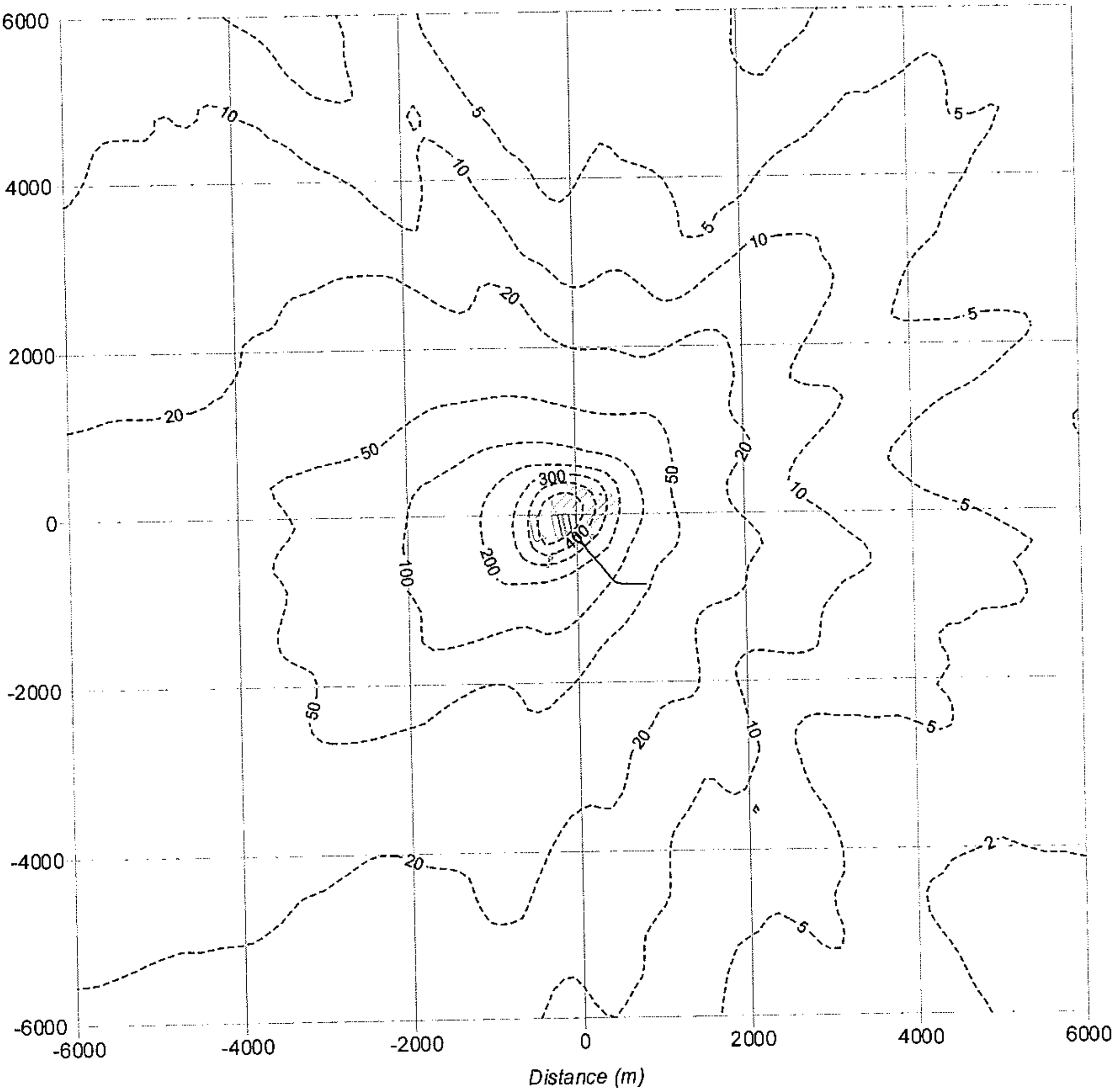

**Predicted 99.9 percentile compliance odour levels, variable emission rate (odour units) - Feedlot B**

**FIGURE 12**



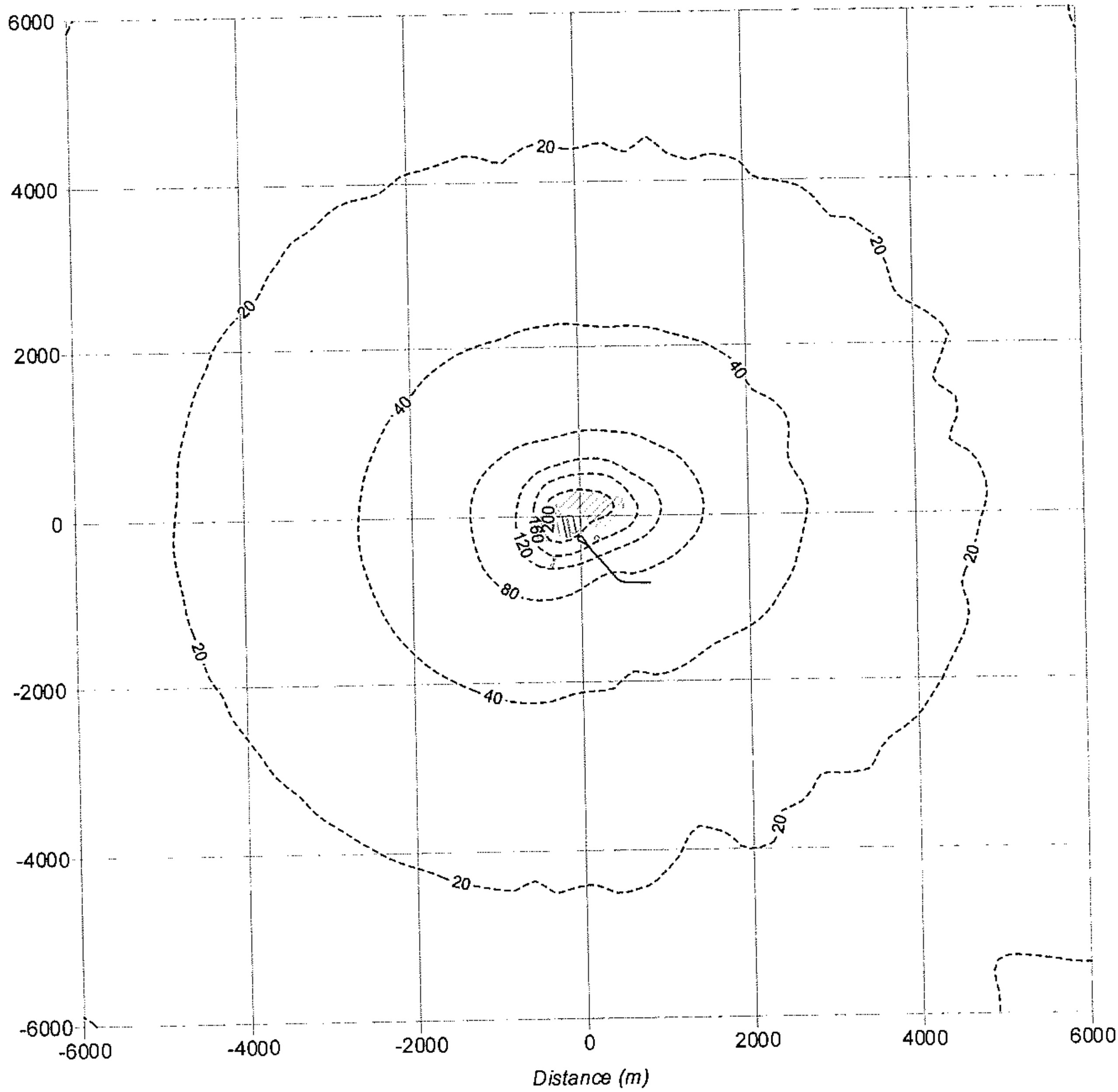

**Predicted 99.5 percentile compliance odour levels, variable emission rate (odour units) - Feedlot B**

**FIGURE 13**



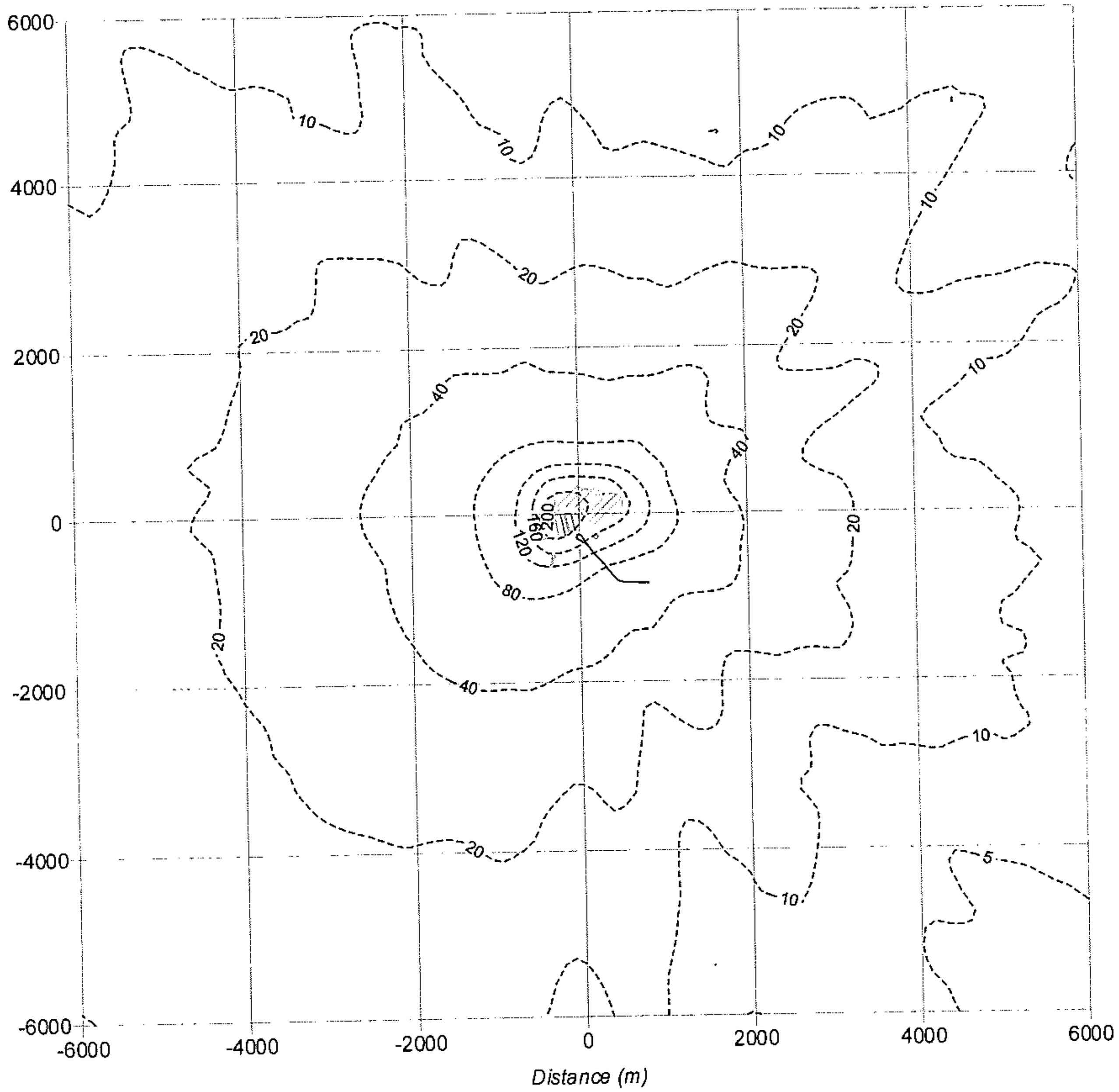

**Predicted 99th percentile compliance odour levels, variable emission rate (odour units) - Feedlot B**

**FIGURE 14**



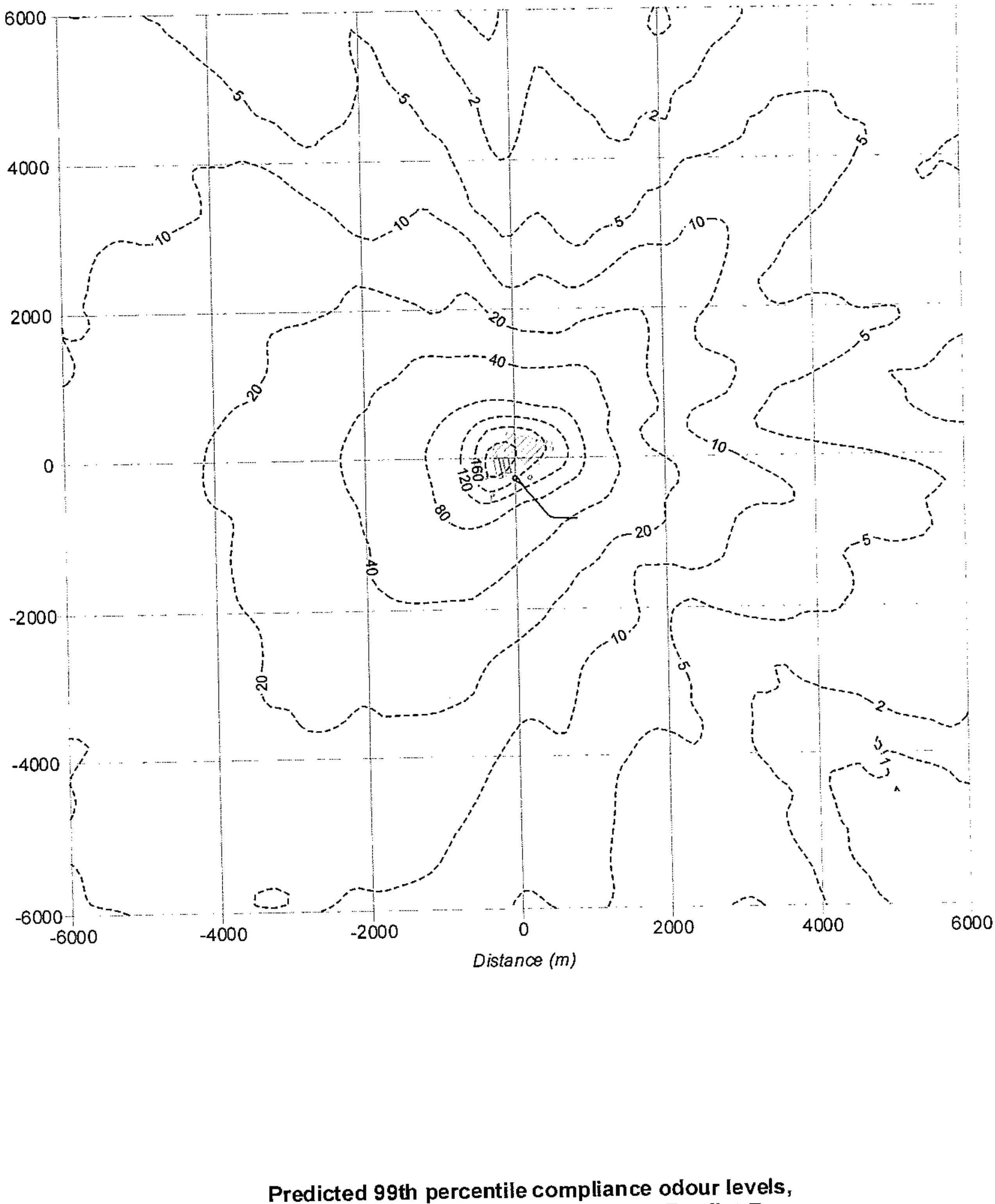

**Predicted 99.9 percentile compliance odour levels, constant emission rate (odour units) - Feedlot B**

**FIGURE 15**



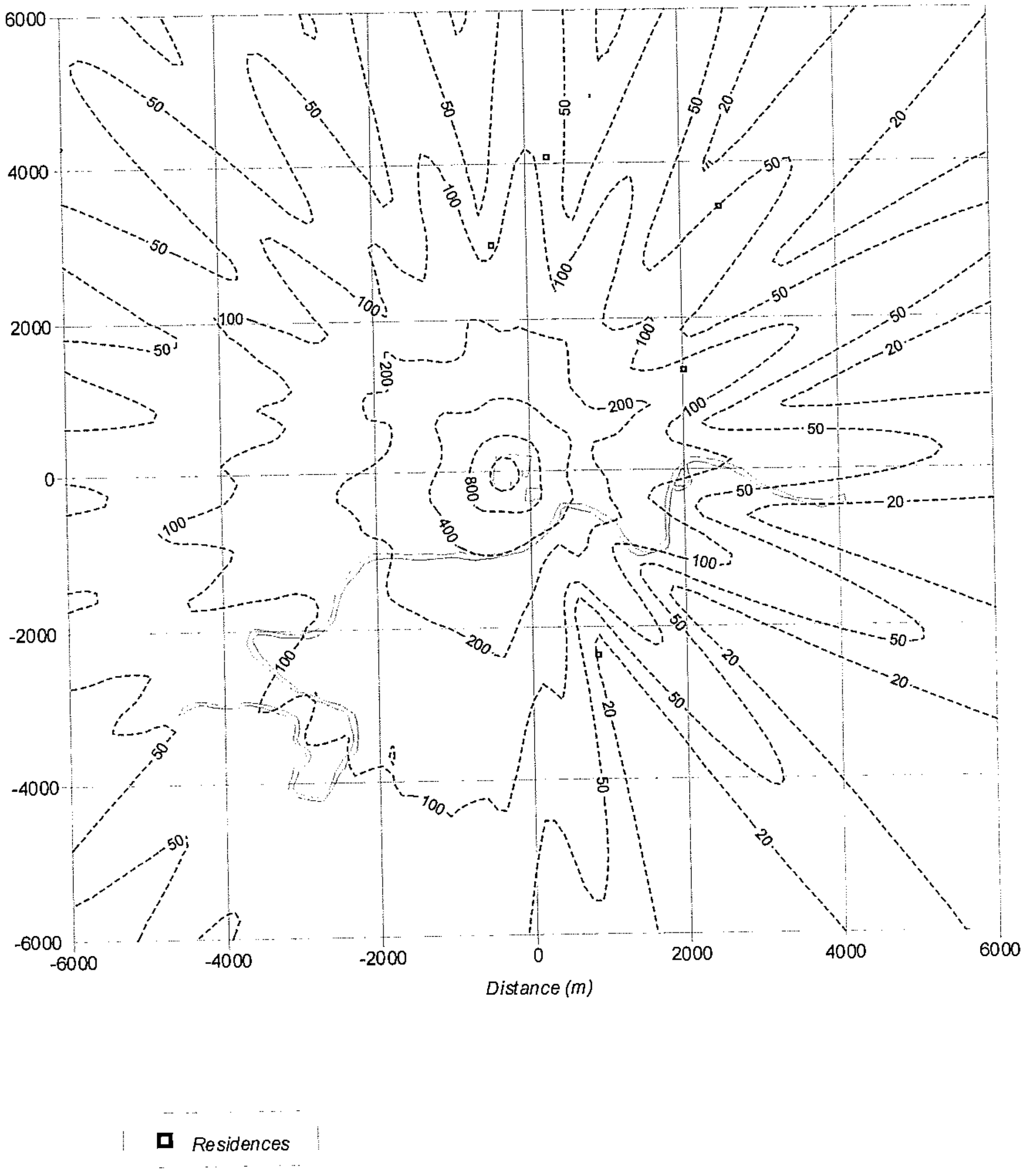

**Predicted 99.5 percentile compliance odour levels, constant emission rate (odour units) - Feedlot B**

**FIGURE 16**



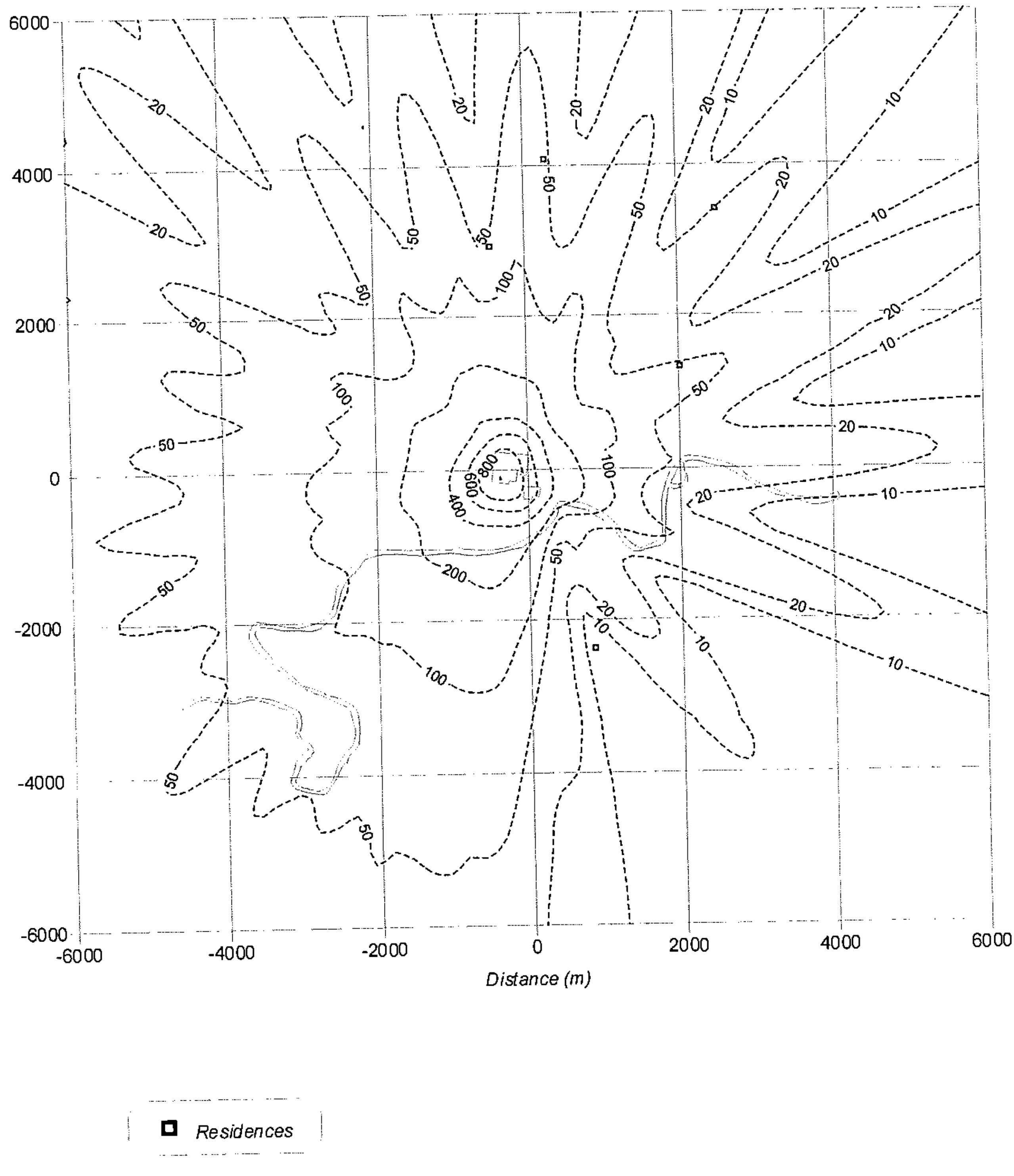

**Predicted 99th percentile compliance odour levels, constant emission rate (odour units) - Feedlot B**

**FIGURE 17**



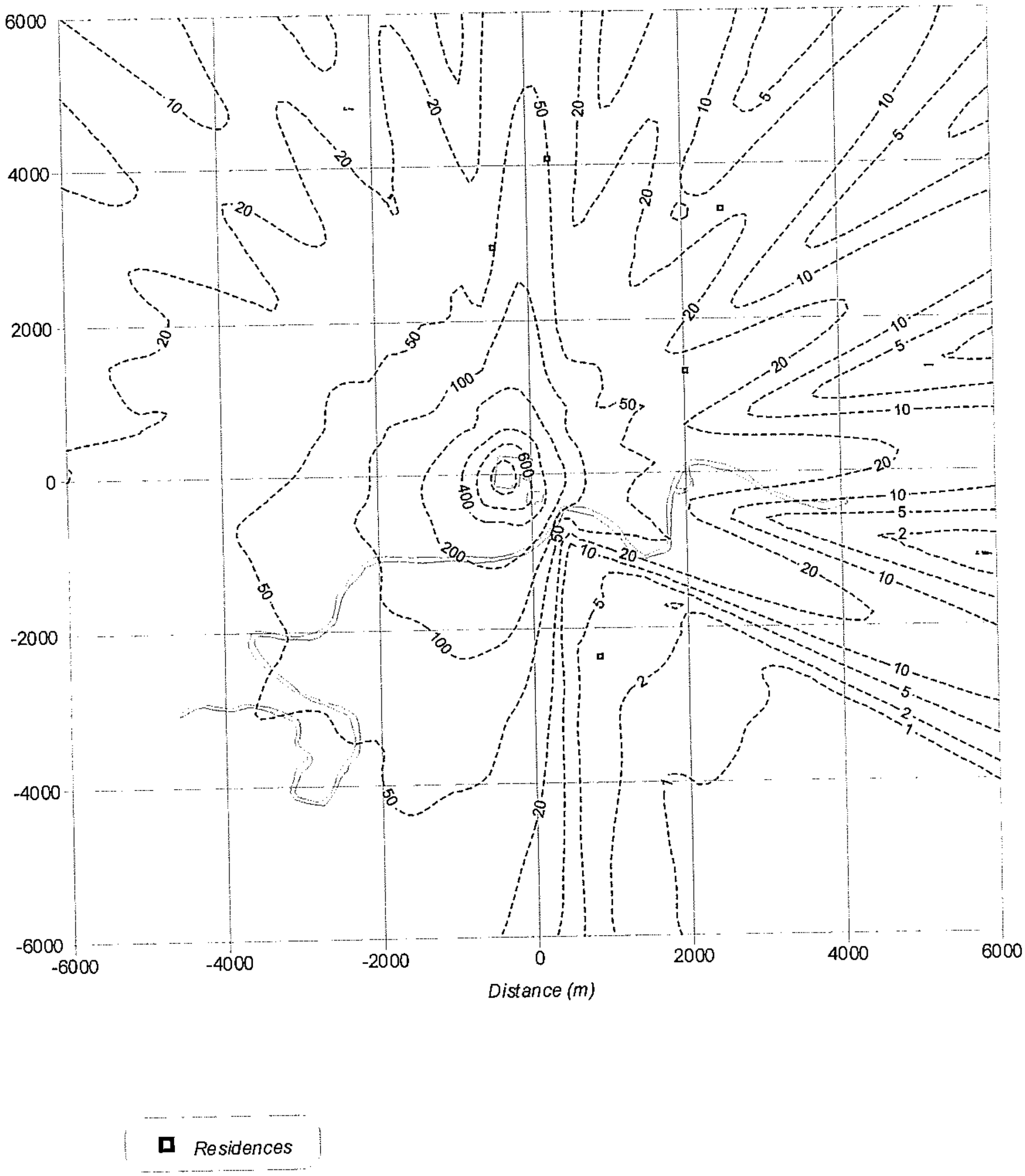

**Predicted 99.9 percentile compliance odour levels, variable emission rate (odour units) - Feedlot C**

**FIGURE 18**



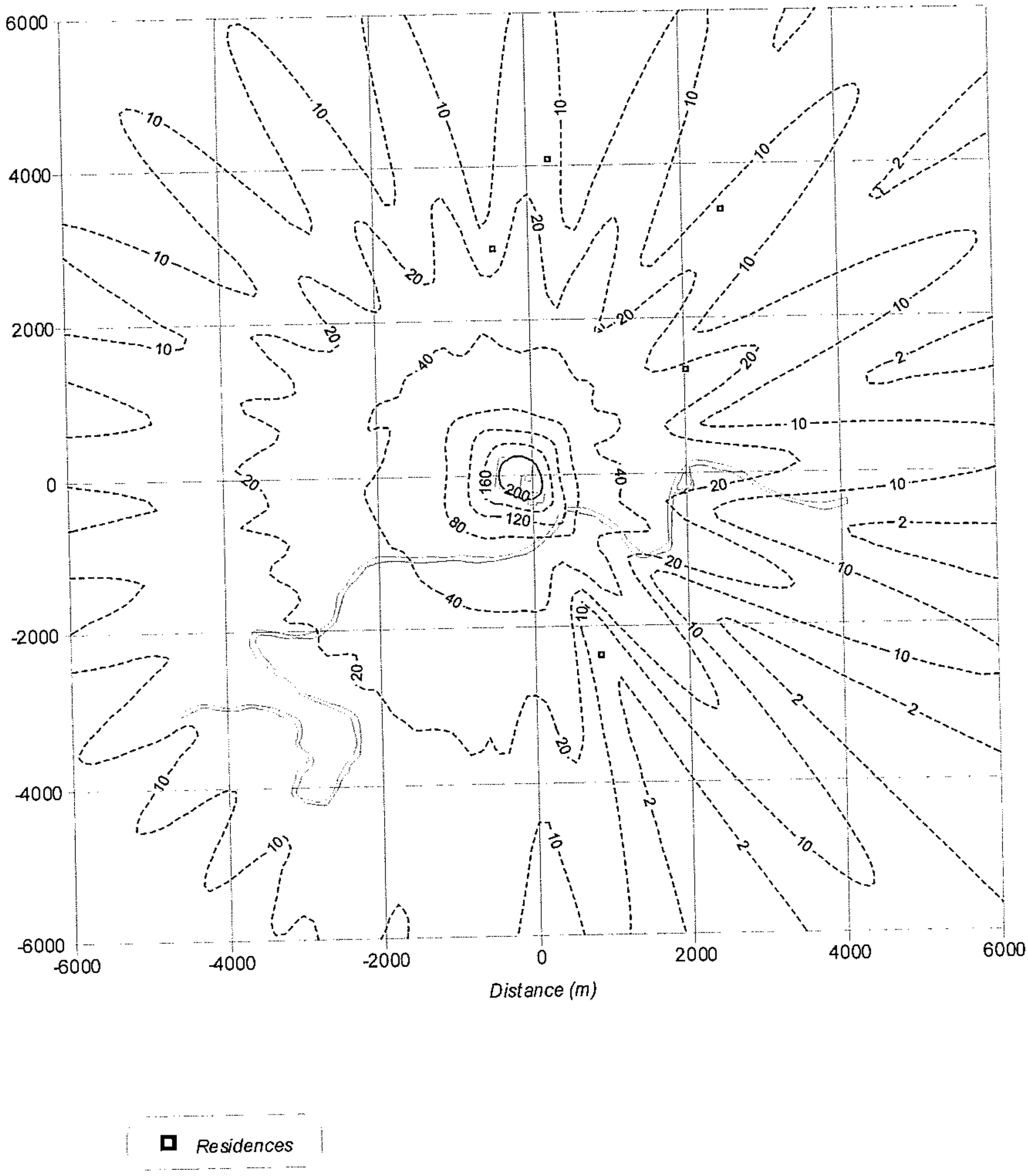

**Predicted 99.5 percentile compliance odour levels, variable emission rate (odour units) - Feedlot C**

**FIGURE 19**



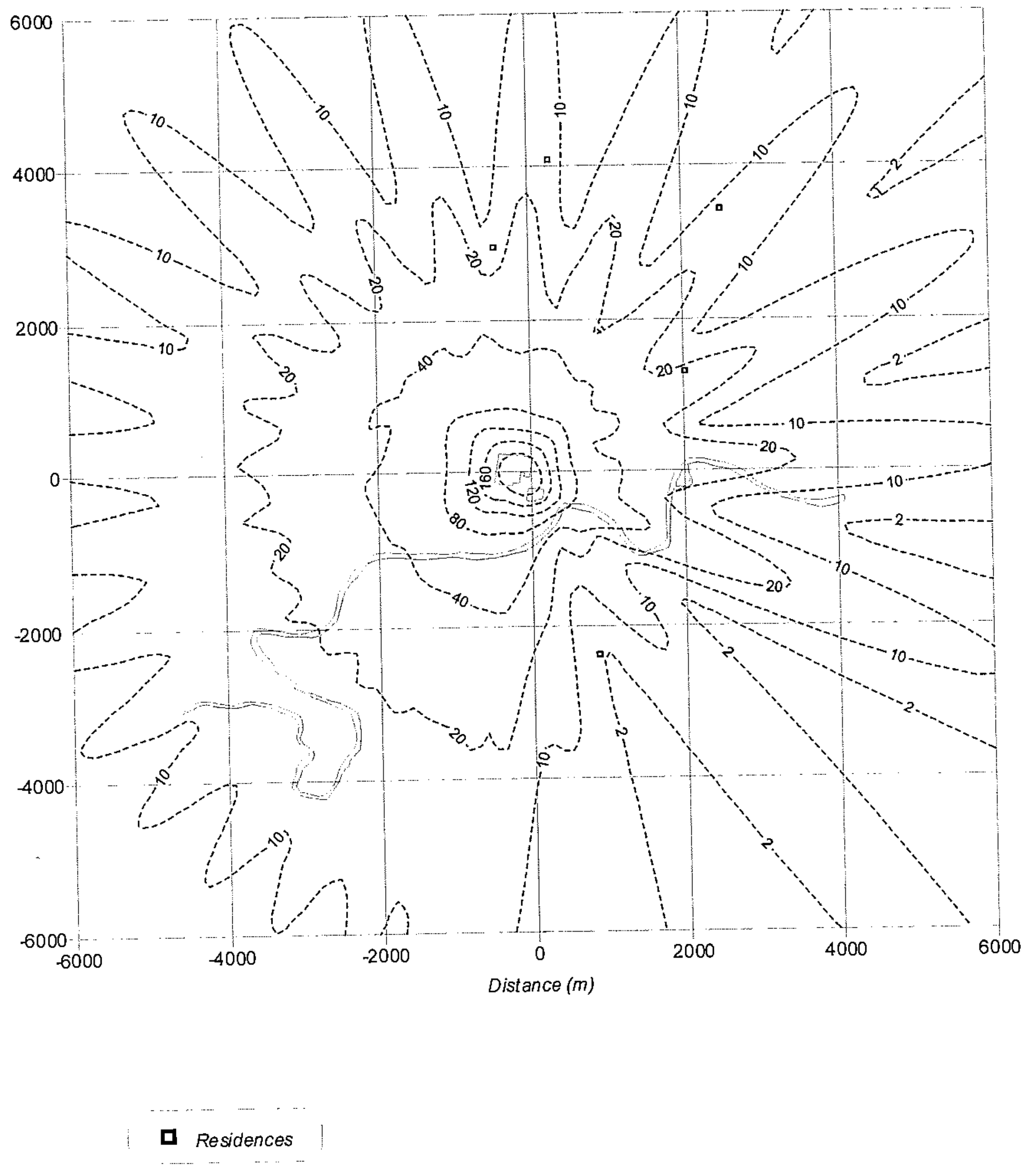

**Predicted 99th percentile compliance odour levels, variable emission rate (odour units) - Feedlot C**

**FIGURE 20**



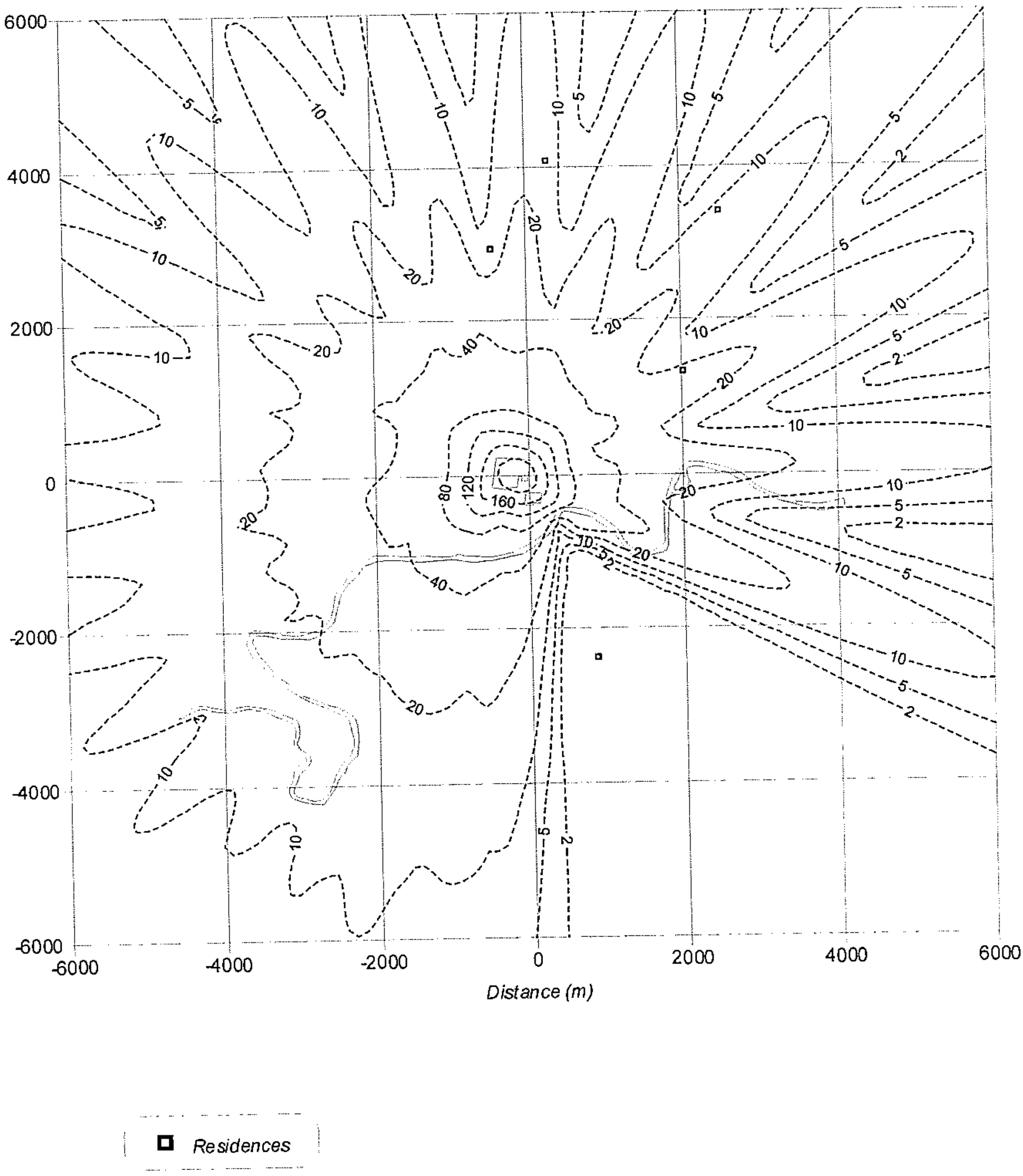

**Predicted 99.9 percentile compliance odour levels, constant emission rate (odour units) - Feedlot C**

**FIGURE 21**



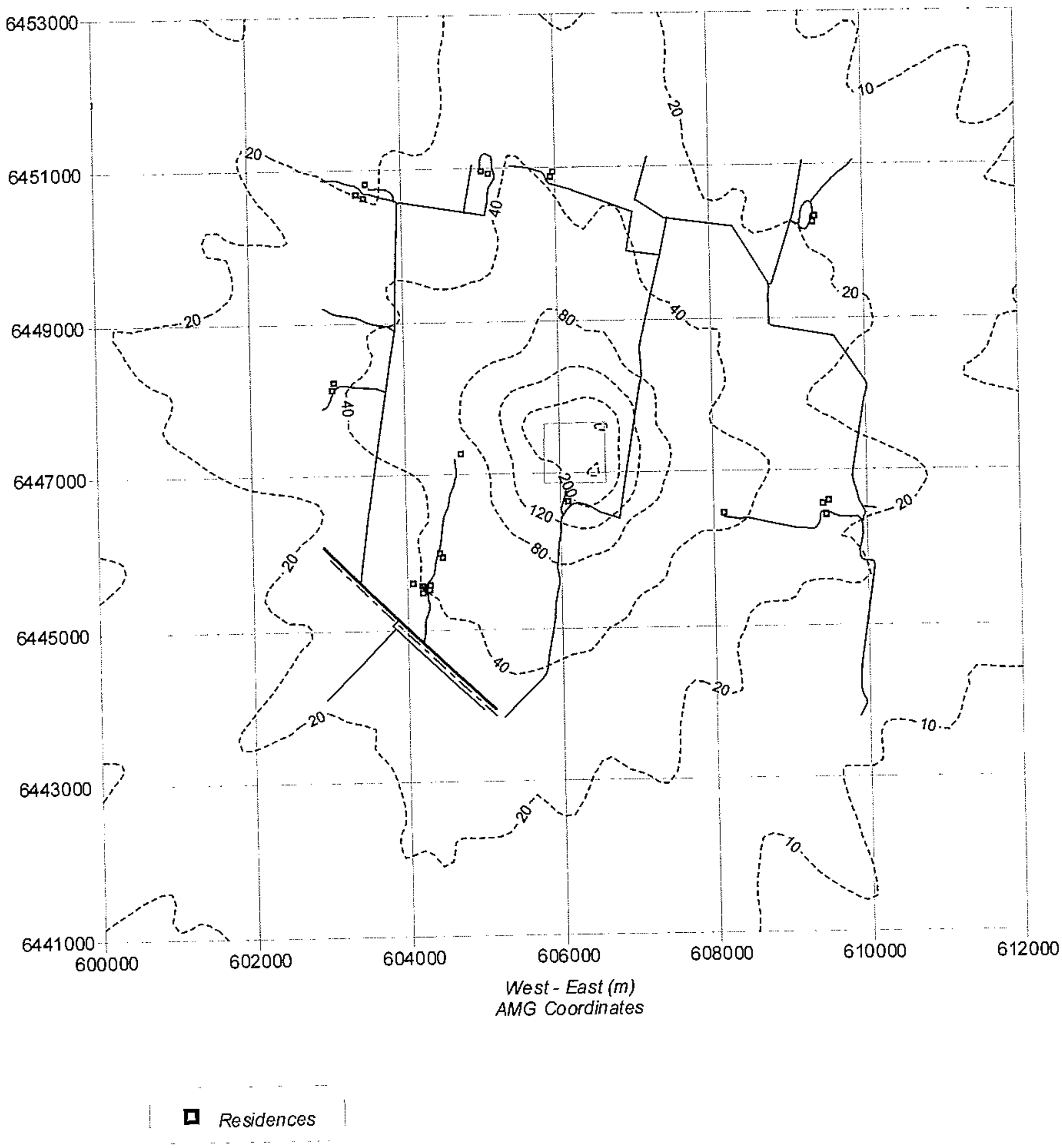

**Predicted 99.5 percentile compliance odour levels, constant emission rate (odour units) - Feedlot C**

**FIGURE 22**



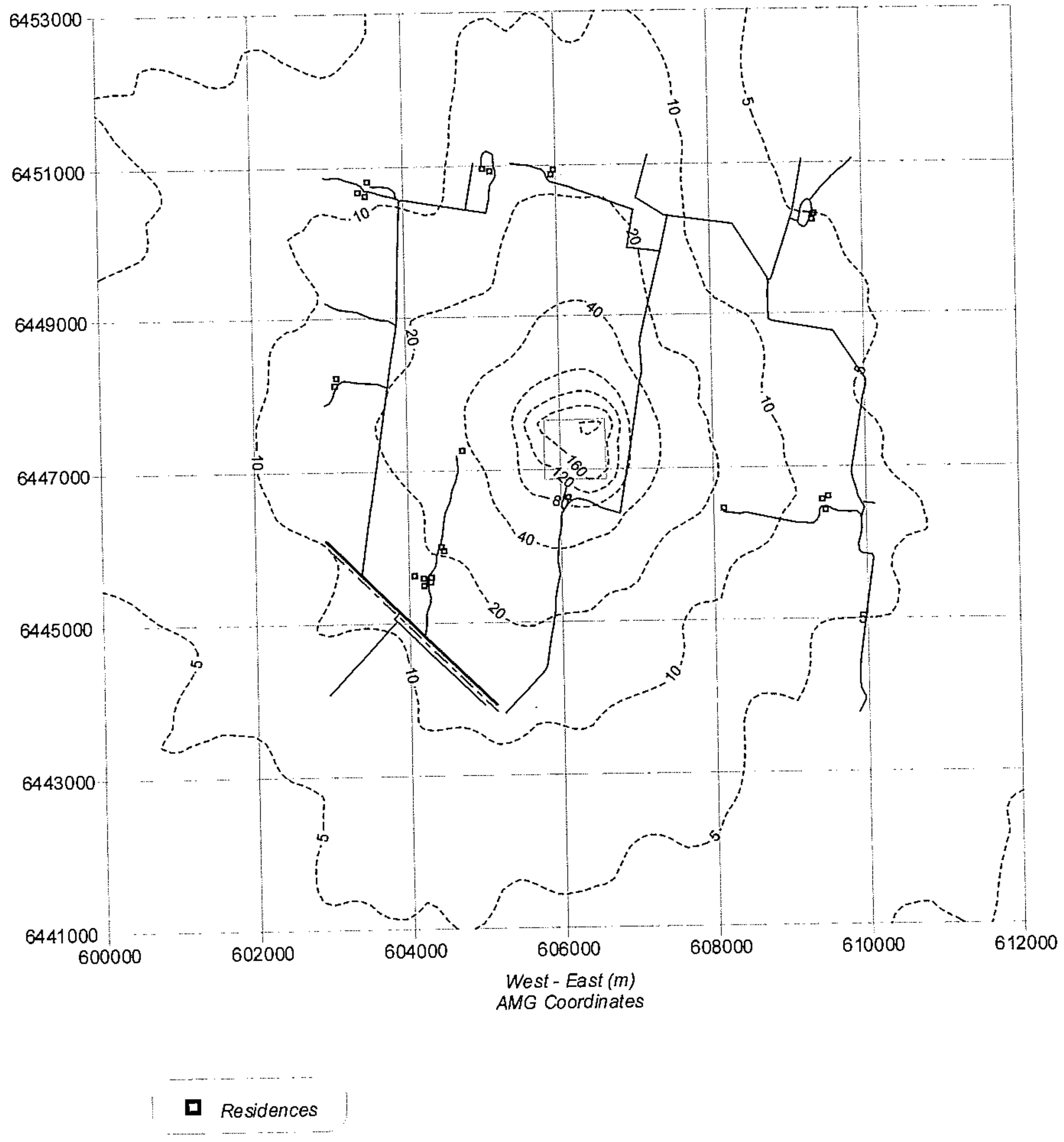

**Predicted 99th percentile compliance odour levels, constant emission rate (odour units) - Feedlot C**

**FIGURE 23**



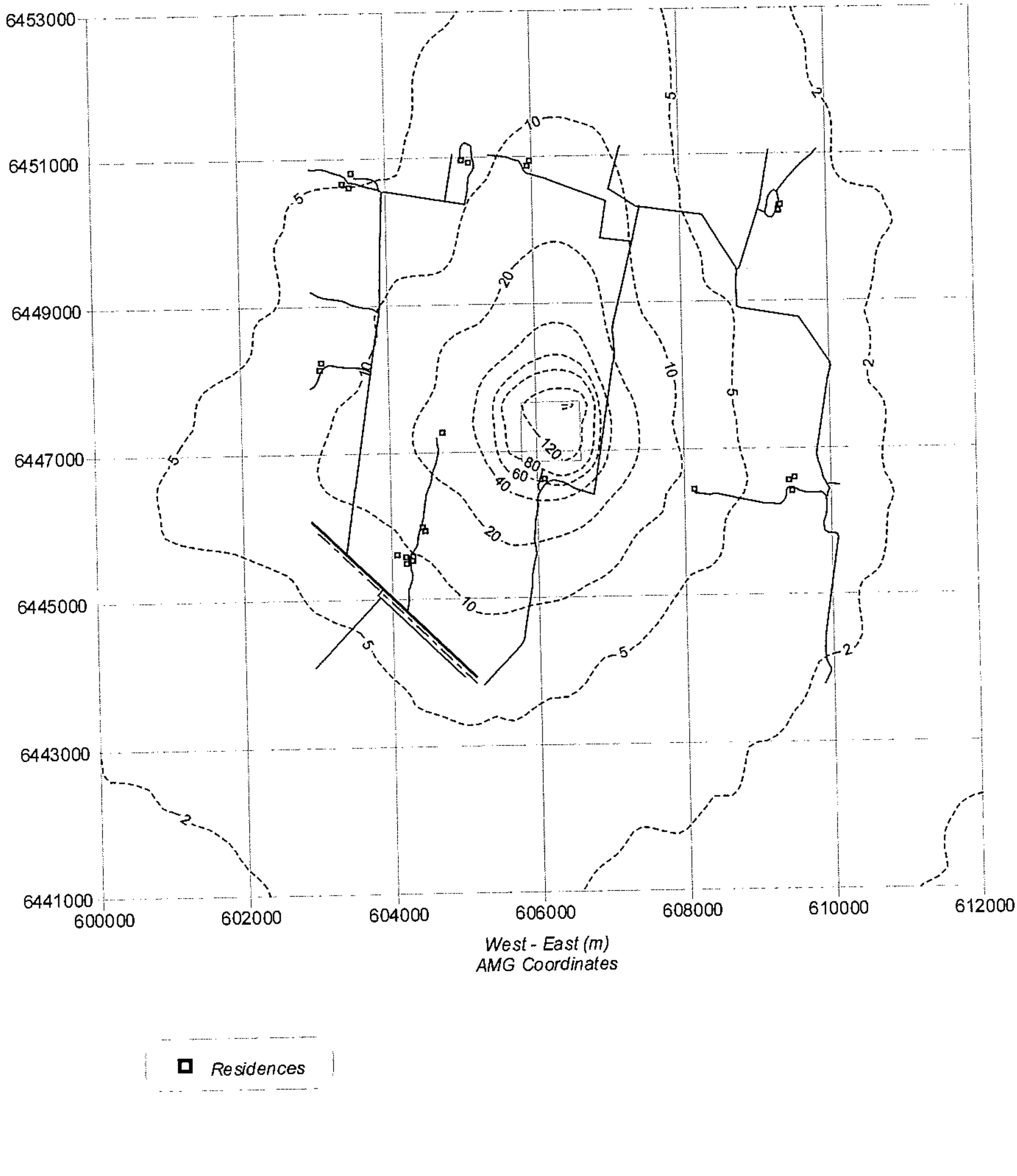

**Predicted 99.9 percentile compliance odour levels, variable emission rate (odour units) - Feedlot D**

**FIGURE 24**



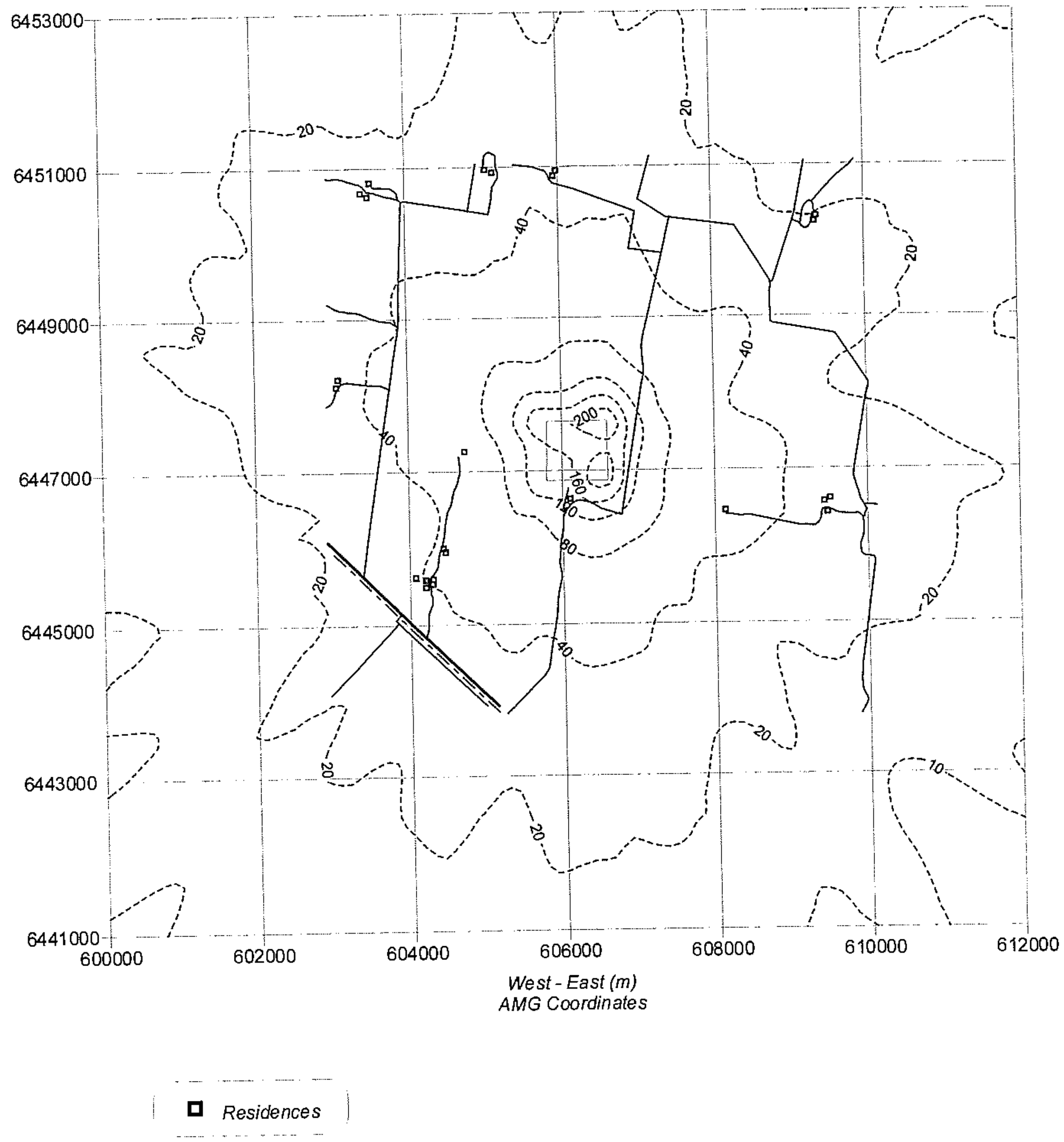

**Predicted 99.5 percentile compliance odour levels, variable emission rate (odour units) - Feedlot D**

**FIGURE 25**



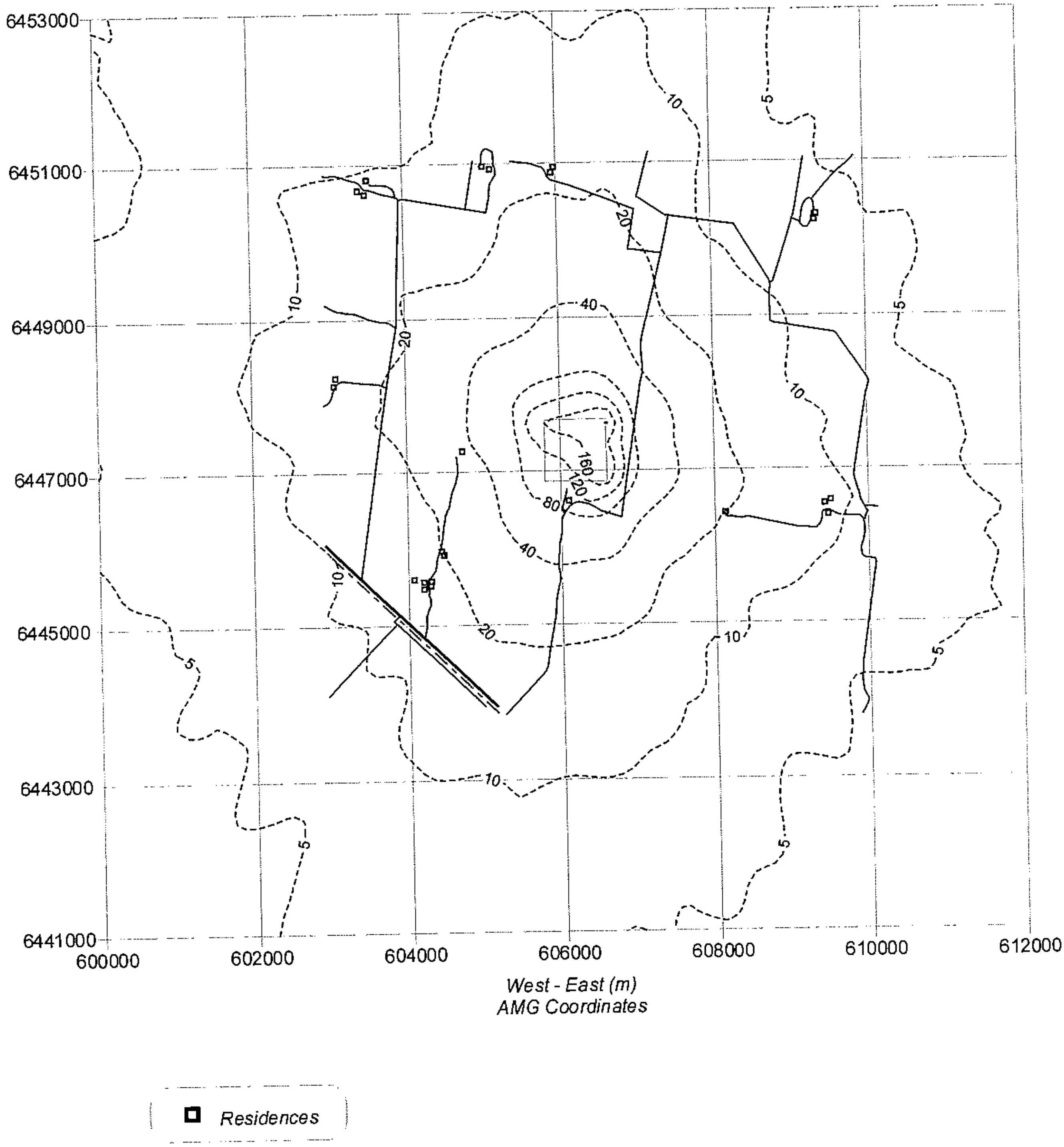

**Predicted 99th percentile compliance odour levels, variable emission rate (odour units) - Feedlot D**

**FIGURE 26**



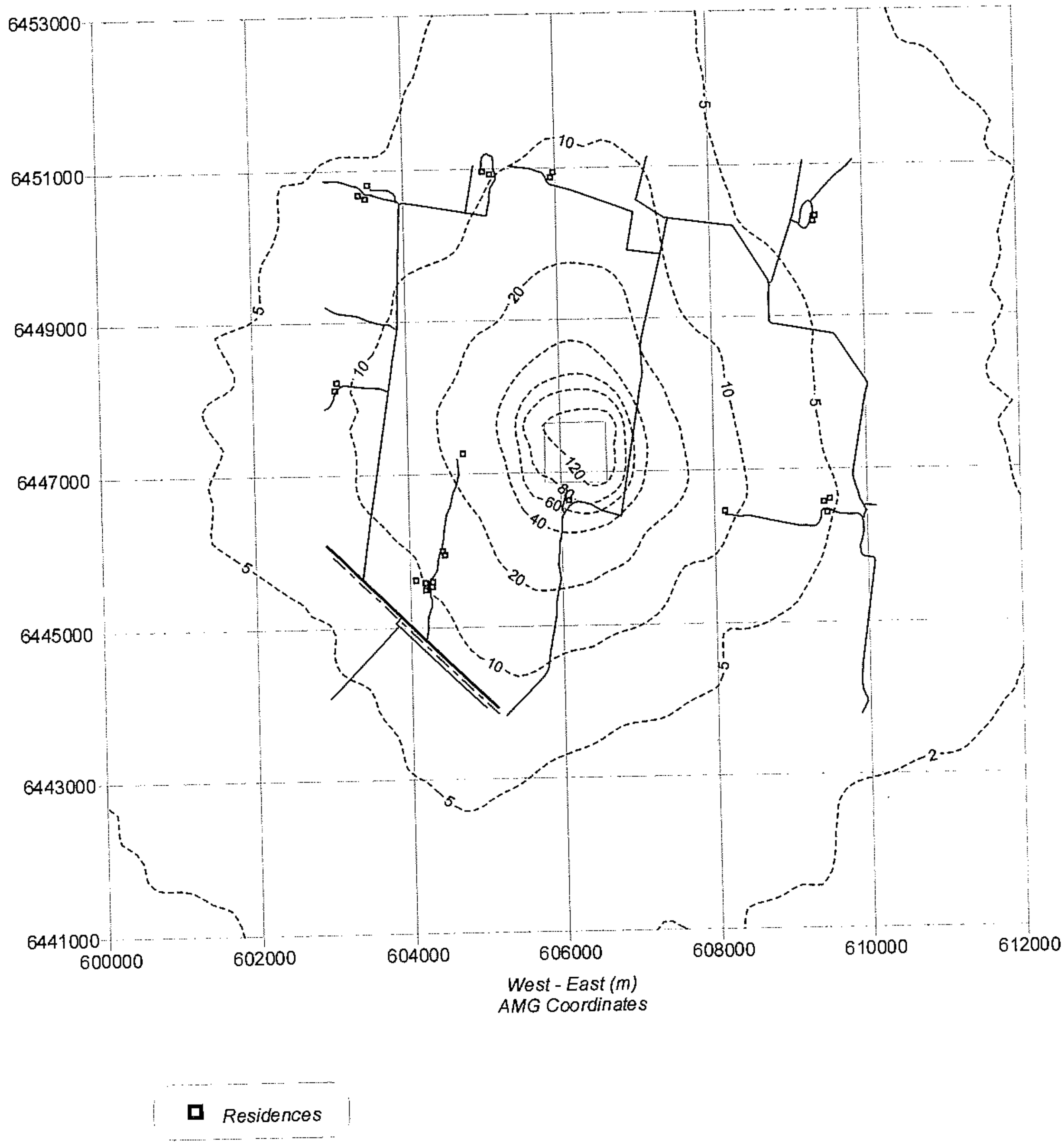

**Predicted 99.9 percentile compliance odour levels, constant emission rate (odour units) - Feedlot D**

**FIGURE 27**



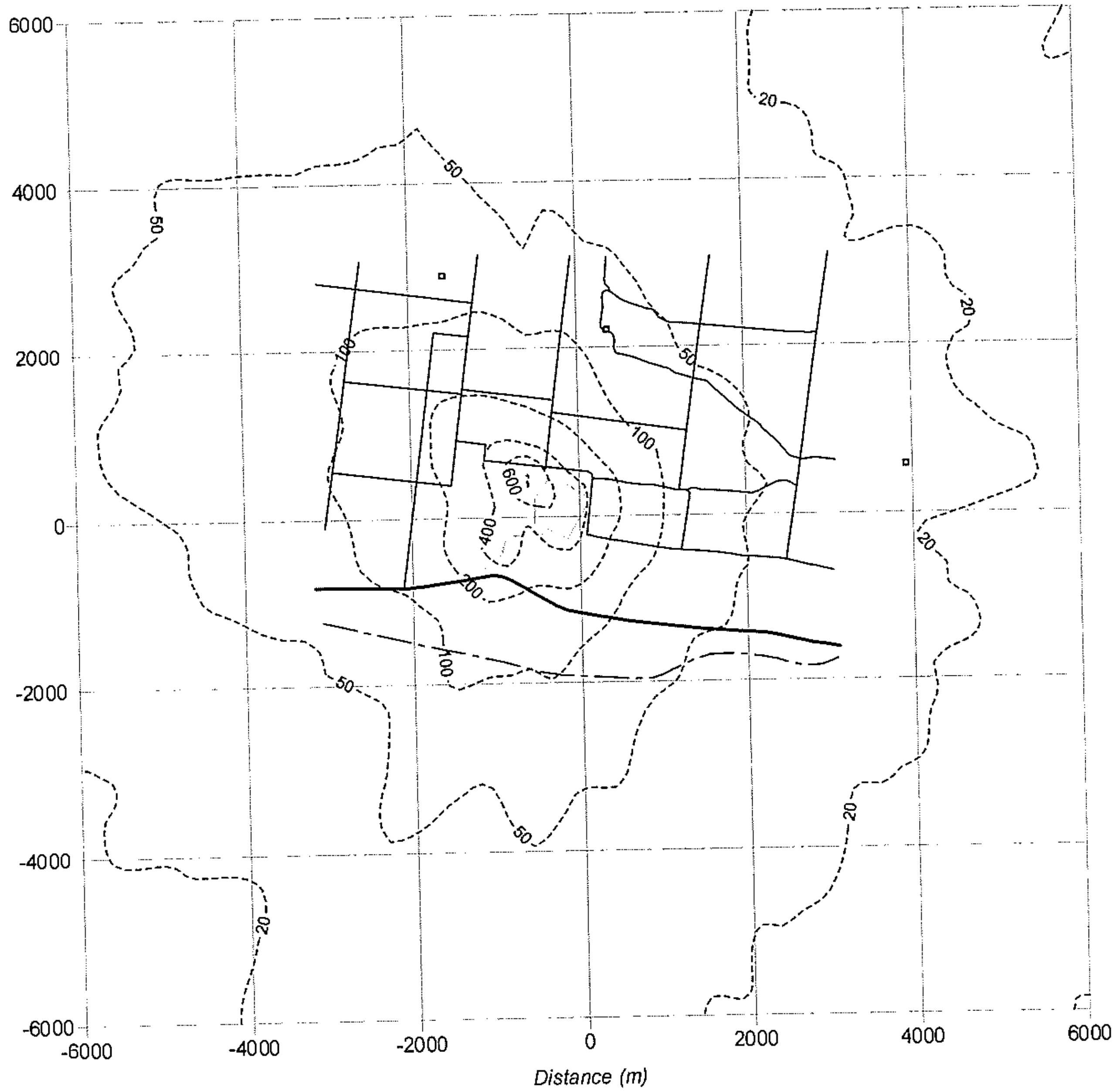

**Predicted 99.5 percentile compliance odour levels, constant emission rate (odour units) - Feedlot D**

**FIGURE 28**



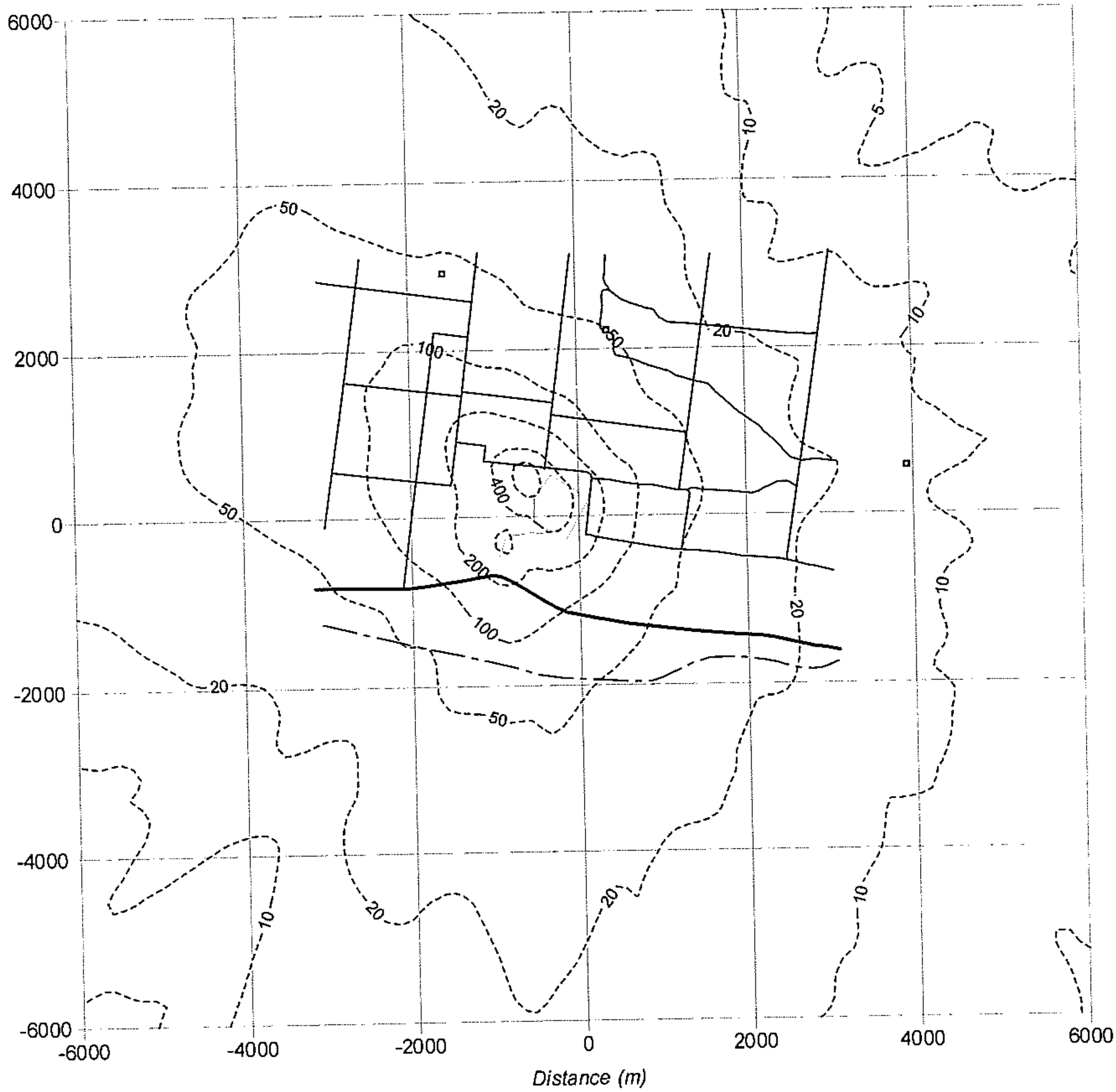

**Predicted 99th percentile compliance odour levels, constant emission rate (odour units) - Feedlot D**

**FIGURE 29**




**Predicted 99.5 percentile compliance odour levels, variable emission rate (odour units) - Feedlot E**

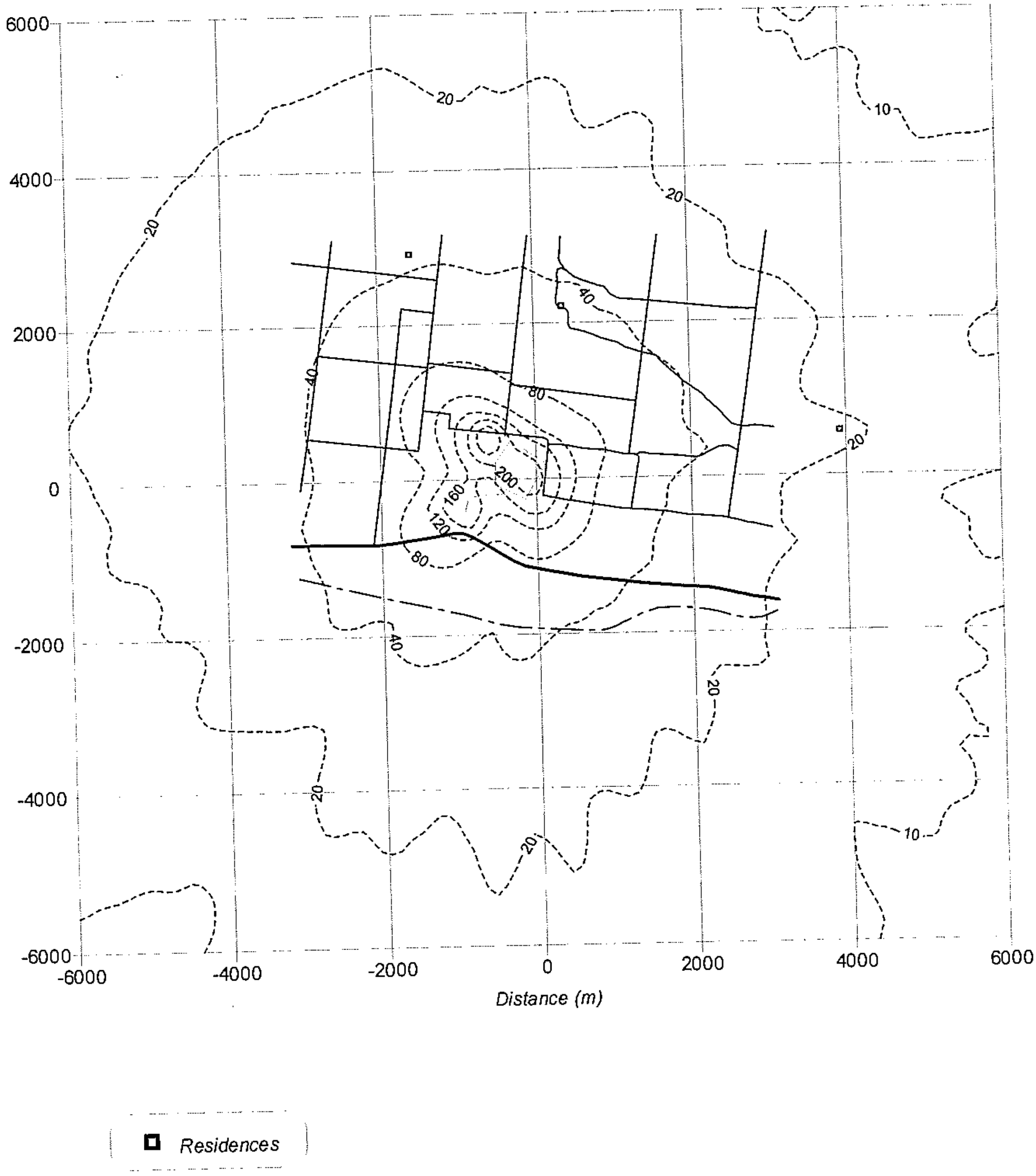
**FIGURE 31**





**Predicted 99th percentile compliance odour levels, variable emission rate (odour units) - Feedlot E**

**FIGURE 32**




**Predicted 99.5 percentile compliance odour levels, constant emission rate (odour units) - Feedlot E**

**FIGURE 34**


**Predicted 99th percentile compliance odour levels, constant emission rate (odour units) - Feedlot E**

**FIGURE 35**