MONETARY VALUATION OF INTANGIBLES

Literature review and pilot surveys

Tranfund New Zealand Research Report No. 98

MONETARY VALUATION OF INTANGIBLES

- LITERATURE REVIEW AND PILOT SURVEYS

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EXECUTIVE SUMMARY

The subject of this Literature Review and Pilot Survey is the monetary valuation of the environmental effects of roads and road traffic on residential land use.

These environmental effects do not have an explicit monetary value so are described as "intangibles". This distinguishes them from other "tangible" costs of roads and road traffic such as highway maintenance costs and vehicle operating costs. As the environmental effects are external to the road providers and road users, they also form part of the "externality costs" of road transport.

The environmental effects may be divided into those for which the severity of the effect varies with the proximity of the roadway to the adjoining land use, and other effects which are not related to proximity, such as road severance of communities. Examples of these "proximity effects" are disturbance to people in their houses from traffic noise, air pollution and visual intrusion.

Methods which are used to place a monetary value on intangibles are collectively referred to as "non-market valuation" techniques. A range of these techniques is reviewed, with particular emphasis on hedonic pricing and contingent valuation. Hedonic pricing attempts to derive monetary values for intangible effects from trade-offs people make between such effects and goods or services which are bought and sold on the open market. Contingent valuation does the same, but by posing questions on hypothetical choices rather than by studying trade-offs actually made.

The most common application of the hedonic pricing method to road traffic disturbance has been through the analysis of house sales to determine a relationship between traffic noise disturbance and house price. The results of these studies have been expressed as the percentage reduction in property value per 1 dBA Leq increase in traffic noise exposure, called the noise depreciation index (NDI). The noise unit dBA L_{eq} is the decibel noise measure (dB), weighted for the frequencies characteristic of road traffic noise (A) and expressed as the energy mean sound level (L_{eq})

A pilot hedonic pricing survey was carried out on 256 properties of similar neighbourhood characteristics in an Auckland suburb, using Valuation N.Z. data on property transactions and by direct observation of features of the properties, the road layout and traffic stream. The practicality of carrying out the survey was demonstrated but an exploratory regression analysis on the data obtained did not yield any clear relationship between property price and traffic disturbance. The authors suggest that a larger number of independent variables and more accurate measurement would be needed if the method is to be taken further.

Nevertheless, hedonic pricing studies of noise disturbance effects on house price carried out overseas over several decades provide the largest pool of research data on the valuation of traffic noise disturbance. Results from these previous studies show the NDI to generally lie in the range 0.08% and 1.05%, with the majority falling between 0.3% and 0.6%.

If a single indicative noise depreciation index is to be adopted for use in cost benefit analysis by Transit New Zealand, a NDI of 0.4% to 0.5% of property value per decibel of traffic noise exposure above the noise background level would represent the consensus from overseas study results. This value is also consistent with the value adopted by those overseas roads authorities which have included a monetary value for traffic noise disturbance in their economic analysis procedures. For various reasons, the authors believe that this value of a general NDI will be conservative and that future research is more likely to lead to an increase in the value. The authors also caution that the NDI can be expected to vary according to the context in which the traffic disturbance occurs. Factors which could lead to such variation include whether properties are rental or owner-occupier, whether the road is on new or established alignment, and whether located in the urban centre or periphery. There is also the possibility that the NDI is non-linear with increasing noise level above the background.

While the results of previous hedonic pricing studies provide a starting point for inclusion of a value for traffic noise disturbance to economic evaluation, and for proximity effects of traffic in general, contingent valuation provides a more promising method for future empirical research. It is recommended that no further empirical investigation using hedonic pricing based on house sales be pursued until the contingent valuation method has been more thoroughly explored.

The Literature Review found few examples where contingent valuation has been applied so far to the environmental effects of road traffic, although the method has had extensive application in other areas of transport benefit analysis, in particular the valuation of travel time savings.

As part of this project, a pilot contingent valuation survey was developed, in which respondents were asked their willingness to pay more for a property with less disturbance from traffic, given that they had made a decision to move house, and that the choices available were similar in all other respects.

Three attributes were included in the choice sets: traffic level, building distance from the road boundary; and degree of visual and acoustic screening. The traffic flow was described as low, medium or high and this description was reinforced by an artist's impression of the road layout showing a no-exit residential street, a two lane collector/distributor road and a four lane arterial.

This pilot survey gave encouraging results, the choice context being sufficiently realistic to be understood by respondents, and the method used to introduce the money variable also being comprehensible and not in a form likely to introduce respondent bias.

Although tested over a very small sample, the numerical results support a proximity cost of traffic disturbance in the range of 0.3% to 1.0% of property value per decibel change in traffic noise exposure with some suggestion of non-linearity. This result is consistent with the findings of hedonic pricing studies conducted overseas, and with the likelihood that hedonic pricing based on residential property value does not fully capture the total value of traffic noise disturbance. It also appears likely that, while traffic noise is a convenient indicator for intangible traffic proximity effects, such costs are perceived at traffic flows below that at which traffic noise falls below the background noise level.

It is recommended that the technique be pursued through a further round of larger scale trials of the survey and analysis method and then, assuming these are successful, proceed to a full scale survey.

A literature review was made of approaches to the monetary valuation of the barrier or severance effect of main roads on communities. Pedestrians, cyclists and even local motorised traffic can experience delays, longer travel distances and difficulty in crossing main traffic routes which leads to isolation of one area from another.

As a result of the review, it is recommended that further investigation be carried out to develop a quantitative method for evaluating severance effects using techniques similar to those employed in some Scandinavian countries. There are three main requisites for such an analysis:

- data on pedestrian and cycle trip patterns in the area of study;
- knowledge of how such trip making is suppressed by a road or traffic barrier, or trips diverted to other destinations; and
- community willingness to pay to reduce the delays and difficulties caused to different groups in the community, such as the young and elderly.

ABSTRACT

Literature on the monetary valuation of the environmental effects of roads and road traffic on adjoining residential land use is reviewed. The application of an hedonic pricing method linking house price differences with traffic noise disturbance is explored for an Auckland suburb. It is concluded that more detailed information on property characteristics, traffic flows and noise exposure and more advanced multivariate analysis would be needed to progress this technique further. However, the literature review leads to a recommended indicative value for traffic noise disturbance of 0.4 to 0.5% of house value per 1 dBA increase in the energy mean sound level (L_{eq}).

A contingent valuation method survey is developed to a pilot stage. The survey context is the house owner's willingness to pay to avoid traffic disturbance in the context of moving to a new property. Traffic disturbance is described in general terms involving attributes of traffic volume, property screening and building set-back from the road boundary.

A review of literature on the monetary valuation of the severance effect of roads on local communities is reported and recommendations made on a possible approach for including this intangible in a cost benefit analysis framework.

1. INTRODUCTION

1.1 Research Objectives

The subject of this research project was the proximity disbenefits of road traffic to residential development, using daytime traffic noise as the principal quantitative measure.

The objectives of the project were:

- To undertake a literature review of proximity impacts and of severance including making contact with overseas researchers and with N.Z. specialists in non-market valuation.

- To design and conduct an hedonic pricing study of residential property values versus the proximity impacts of traffic.

- To design and conduct a contingent valuation study of the environmental and proximity impacts of adjacent traffic on occupiers of residential property.

- From the results of the above to draw conclusions on the monetary valuation of the disbenefits to occupiers of residential property of adjacent road traffic.

The extent of achievement of these objectives is summarised as follows:

- A literature review was completed and contacts made with N.Z. and overseas researchers.

- A survey of residential property values and characteristics was carried out and a preliminary analysis using the hedonic pricing method was made. Any effect of traffic on property value for the houses included in the survey was found to be either insignificant or masked by other factors which influence house value.

- The literature review was found to be sufficiently convincing that contingent valuation methods would be superior to hedonic pricing and that the hedonic pricing approach should not be pursued further.

- Two stages of piloting of a contingent valuation survey were completed; while the pilot surveys were insufficient to provide monetary valuation results, they highlighted the practical and theoretical problems of applying the contingent valuation method to the proximity effects of traffic.

- A general conclusion reached was that a well designed and executed CV survey should be able to elicit householders' valuation of the perceived disturbance from adjacent road traffic; however it may be unrealistic to expect the method to produce separate valuations for each environmental effect (noise, air pollution, visual intrusion, insecurity etc); also a CV survey would not elicit valuation of unperceived damages, such as health effects from air pollutants.

- A workshop was held with other researchers active in the field of non-market valuation to discuss the results of the literature review and pilot stages of the study. A number of suggestions were made concerning future direction of the project and development of techniques.

The following report discusses the progress towards achievement of the objective of ascribing monetary values to intangible effects of roads and traffic in New Zealand, and makes recommendations regarding further work in this field.

1.2 Background

The subject of this Literature Review and Pilot Survey is the monetary valuation of the environmental effects of roads and road traffic on residential land use.

These environmental effects do not have an explicit monetary value so are described as "intangibles". This distinguishes them from other "tangible" costs of roads and road traffic such as highway maintenance costs and vehicle operating costs. As the environmental effects are external to the road providers and road users, they also form part of the "externality costs" of road transport.

The environmental effects may be divided into those for which the severity of the effect varies with the proximity of the roadway to the adjoining land use, and other effects which are not related to proximity, such as road severance of communities. Examples of these "proximity effects" are disturbance to people in their houses from traffic noise, air pollution and visual intrusion.

Social cost benefit analysis (SCBA) is the technique used by Transit New Zealand for the economic assessment of road projects, and is an important factor in the comparative ranking of projects and allocation of funds. SCBA has been used for project evaluation purposes by New Zealand roading authorities for about 25 years and is also widely used by similar agencies in other countries. It has many advantages as a decision-making tool but can be criticised on various grounds of theoretical and practical implementation. It is not the function of this report to provide a general review of the strengths and weaknesses of SCBA. These can be found extensively in the technical literature. However, while the method has its difficulties, it brings a formal rigour to the assessment process which helps avoid arbitrary, narrowly focused or partial judgements when a choice has to be made between competing uses of public funds.

The application of SCBA requires that all of the costs and benefits be measured in a common *numeraire* or unit of measure. Monetary values are normally the most convenient common unit of measure and, for SCBA to be applied fully, all inputs and outputs have to be expressed in dollar values.

Where some project outputs are intangible, an immediate problem is created in bringing these outputs into a common scale of reference. This has given rise to the use of various forms of presentation of project outputs where there is no common scale of measure. The "project balance sheet" is one such method, which has been used by Transit N.Z. in its Project Evaluation Manual (Transit N.Z. 1991). Various decision analysis techniques have also been devised to select and rank projects which include a variety of intangible and dissimilar outputs. However, whichever method is used, it is difficult to avoid making some explicit or implicit value judgement as to the worth of intangible effects as compared with tangible costs.

As there is, by definition, no market value for an intangible, the process of establishing a monetary valuation must involve a study of trade-offs between the intangible concerned and other items which do have market values. This is already done extensively in transport project appraisal; for example in the valuation of travel time savings and, more recently, in the social value of reducing the risk of fatal injury accidents (known as the "value of statistical life"). Extending these non-market valuation techniques to other commonly occurring intangibles such as traffic noise disturbance may be regarded as a logical next step.

1.3 The Range of Intangible Effects of Roads and Traffic

The Project Evaluation Manual (Transit N.Z. 1991, Appendix 7) identifies the intangible effects of traffic streams as:

- traffic noise and vibration
- community severance otherwise known as "barrier effect"
- local air quality impacts (for example: carbon monoxide, nitrogen oxides, hydrocarbons, lead and other particulates)
- water quality impacts - from discharges onto the road
- dust from unsealed roads on crops, road users, adjacent residents
- visual impact of the road, road furniture, road traffic
- effect on special areas: historical, cultural, aesthetic and amenity values
- ecological impact on surrounding flora and fauna
- psychological stress from road designation or forced property purchase
- overshadowing of property
- isolation
- carbon dioxide emissions (global climate change effects)

Further additions may be suggested. Feelings of stress, intimidation or insecurity can be caused to those living adjacent to the road (*e.g.* concerns for young children), to pedestrians and cyclists, from other motorised traffic. Stress is also a factor for drivers of motorised vehicles, particularly in dense fast moving traffic streams, where there is a high proportion of heavy vehicles or where the road is unfamiliar.

The subject of this project, the proximity effects of traffic on residential development, covers only a part of this list of intangibles. Intangible effects on road users, on non-residential land use, and on natural ecosystems are not included. Road construction impacts are also excluded as are global environmental effects.

The methods used to establish monetary valuation in this study rely on the values revealed through choices made, or on the stated preferences, of those affected. This limits the intangible impacts which can be studied to those which are perceived by people when making choices or responding to questions asked of them. Misperceived or unperceived effects will be absent from any inferred monetary valuation.

A good example of unperceived effects are vehicle exhaust emissions. There is now emerging evidence that some emission components such as inhalable particulates and certain polycyclic aromatic hydrocarbons are more damaging than had been appreciated. As these damages are largely unperceived at present by the general public, valuation methods which rely on public perceptions will be of little use in establishing a social value.

2. LITERATURE REVIEW

2.1 Introduction

2.1.1 Scope

The literature review focused on applications of HPM and CVM in the context of transport and environmental effects. There is an extensive literature on non-market valuation methods and a number of main strands of research and application can be observed.

For the proximity effects of traffic, a large area of research through the 1970s and 1980s focused mainly on road traffic and other transportation noise (air and, to a lesser extent, rail) and the use of hedonic pricing. This was the focus for the literature review.

A second main area is the literature on valuation of travel time and, associated with this, the value of preventing statistical injury and death (so-called "value of life"). Each topic has been the focus for research undertaken by Transit New Zealand and the Land Transport Safety Authority and this literature is not reviewed here. Value of travel time studies (VTTS) incorporate both revealed and stated preference methods, and the empirical findings have been integrated with the theory of welfare economics. VTTS and VOL are themselves a subset of the wider field of study of travel choice behaviour.

A third main area of literature and application of non-market valuation lies in the application of HPM and CVM to the natural environment, particularly for issues such as the protection of wilderness areas and endangered wildlife. This is perhaps the most controversial area of application of non-market valuation theory, since it deals with the societal value of environmental "assets" which may seldom if ever be experienced by those whose valuation is sought. There are lessons to be learned from this debate on non-market valuation applied to non-use values. However it is not the purpose of this report to review this subject area.

2.1.2 Literature Search

The literature search was carried out in 1992, at the start of the project. There has been some limited updating prior to publication of this report.

An on-line computer database search was arranged through TELIS. The subject matter proved a difficult one in which to develop a search protocol and, although a large number of references were identified, many of these were only of peripheral interest. Most of the useful literature on the subject was obtained through direct contacts with other researchers, from technical papers already held, and by manual search of library sources.

The literature review identified research in progress in the United Kingdom on the topic of monetary valuation of intangibles for the U.K. Department of Transport by the Transport Research Laboratory (TRL) in conjunction with the University of East Anglia and contact was established with the project team. However, this programme of work was later reorganised and did not appear to have gone beyond a pilot stage.

Contacts were also made with the Australian Road Research Board, Vic Roads, and the Swedish Road and Traffic Research Institute (VTI). ARRB and VTI were not active in this area. Vic Roads proved helpful providing a copy of a recent Australian study on the cost effectiveness of noise amelioration measures as well as referring the team back to the U.K. researchers. Subsequently, the Victoria Environmental Protection Authority carried out a major piece of investigative research, the "Victoria Transport Externalities Study" (Victoria EPA, 1994).

In Canada, the Ministry of Transportation and Highways of British Columbia had carried out a literature review on the costs of the environmental impacts of transport, and also provided a useful database of technical literature on the topic.

The following section summarises the findings from a review of the technical literature.

2.2 Methods of Valuing Intangibles

2.2.1 Acceptability Criteria for Monetary Valuation Methods

During the last ten years or so, significant progress has been made in the development and testing of techniques designed to assign monetary values to environmental effects. Questions about the economic value of environmental effects have spilled over into other deeper questions about values, ethics, equity and individual rights. It is not surprising therefore that there is a lack of consensus over what exactly is meant by the term "environmental value". In response to the uncertainties Turner and Hargest set out four, not necessarily mutually exclusive, general acceptability criteria for monetary valuation methods (Turner and Hargest 1990):

- Technical - the reliability and validity of the method in a technical sense;
- Institutional - acceptance by the decision-making agencies, and the wider public;
- Complexity - degree of specialised practitioner skills required to operate the method, its "user friendliness"; and
- Financial cost of undertaking empirical studies.

Similar criteria were recommended by the Standing Advisory Committee on Trunk Road Assessment in the U.K. (SACTRA 1992). Having, in prior statements, taken the position that environmental benefits or costs should not be evaluated in monetary terms, this report reached the following conclusions:

> "There is no legitimate objection in principle to the use of monetary values for evaluating as many of the environmental effects of road schemes as lend themselves to that technique, even if others cannot be so valued.

There are great advantages to be gained from extending monetary valuation as far as it is reasonable to do so.

There is a danger, which must be recognised, that as more environmental effects are introduced into cost benefit analysis, a bias in favour of those effects may result. Those which are not valued must still receive their due importance in the appraisal."

SACTRA also set out criteria that must be satisfied for any methods suggested for monetary valuation and project assessment which were:

"Our views on the environmental assessment system that we need may therefore be expressed in these terms:

- First, it must derive from explicitly stated policy objectives. Its logic must be consistent with those objectives, and it must provide information concerning the degree to which the objectives are fulfilled by different schemes (including 'Do Nothing' or 'Do Minimum') from which a choice is being made.

- Secondly, it should ensure that every relevant environmental effect is identified and that all significant (or potentially significant) effects are fully and accurately described and measured in appropriate terms.

- Thirdly, it should be based on real evidence and the highest possible standard of scientific and technical work.

- Fourthly, it should be practical. The resources and time necessary to operate it should not be out of proportion to the importance of the issue involved, or greater than the cost of the outcome.

- Fifthly, it should be capable of being applied consistently between different alternatives, and between decisions taken at different times in respect of other proposals.

- Sixthly, it should be acceptable both to professional people and to the general public. To this end, the value judgements and technical assumptions made, and the methods used, should be explicit, open to scrutiny, challenge and possible revision.

- Finally, the language in which the appraisal is set out should be clear and non-technical, so that the basis upon which decisions are taken is open and capable of being generally understood."

2.2.2 Approaches to Monetary Valuation

Pearce and Markandya (1989) identified three basic approaches to securing monetary measures of benefits in the absence of markets. These were:

- to look for a surrogate market in which the willingness to pay for environmental quality was derived from the trade off behaviour against some related marketed good(s); these revealed preference approaches included the facilities exclusion, travel cost and hedonic pricing methods.

- to create a hypothetical market for the environmental good by responses elicited from a sample of the population on questions which explicitly or implicitly traded off the environmental good with market goods. These stated preference techniques included transfer pricing and contingent valuation methods.

- the dose/response approach in which a physical manifestation of the environmental effect and its associated costs were used to infer a market value. The response was in the form of a damage function to which unit damage costs were applied. The unit damage costs were those of prevention or mitigation of effects, or replacement of the damaged resource, or established through a willingness-to-pay method as in (i) or (ii) above.

A review of monetary valuation techniques (Rendel Planning 1992) added a further approach of "public preference value identification via expert opinion and/or political weights". Each of these approaches is considered briefly below.

2.2.3 Surrogate Market Methods

This approach is to seek a market in which the non-marketed effect is implicitly traded off against some other market good or service.

2.2.3.1 Facilities Exclusion

One form of surrogate market has been called "facilities exclusion". In this method the market price of physical measures taken to nullify the adverse environmental effect has been taken as a measure of the environmental cost (Alexandre and Barde 1987). Examples of physical measures are the erection of a solid barrier to shield property from traffic noise, or double glazing of windows. Such a study would explore the cost of shielding *voluntarily* put in place by the householder, and use this as an indication of the worth to that household of the level of protection purchased.

Alexandre and Barde (1987) noted that the facilities exclusion approach has the following limitations in respect to traffic noise:

- The facilities purchased may have benefits other than noise reduction (*e.g.* acoustic insulation also provides some thermal insulation) leading to an over-estimation of the value attributed to noise reduction.

- The facilities are generally only capable of reducing noise experienced inside the building. The method therefore only provides a lower bound for the valuation of the social cost of noise as it does not capture the disamenity of noise in gardens and on balconies where there is probably as much expectation of peace and quite as there is indoors.

Starkie and Johnson (1975) and Himanen *et al* (1989) in Norway have applied the facilities exclusion method to value the disbenefits of traffic noise. The latter study used insulation cost information published in a 1986 Swedish report (anon, 1986) and applied this to the Norwegian situation, and arrived at a total annual value of traffic noise of 1,150 million Finnish marks (N.Z. $450 million).

The facilities exclusion approach, although simple by nature, has been used in relatively few of the studies reported internationally, probably because of its recognised limitations. As well as the deficiencies noted above, perhaps the biggest drawback with this method is that pointed out by Alexandre and Barde (1987), that it provides only an average valuation of noise for a specific quantum of noise reduction so does not identify the marginal values applicable over the range of noise exposure.

2.2.3.2 Travel Cost Method

Another example of a surrogate market method is that group of research studies which have attempted to infer the value placed on environmental quality or recreational pursuits using the "travel cost" method. A valuation of the environmental good is inferred from the traveller's willingness-to-pay to visit a remote attraction, the WTP being expressed through travel cost, a combination of out-of-pocket costs and perceived opportunity value of time. The travel cost approach is inappropriate to the study of traffic noise disturbance to residential land use, so is not reviewed any further in this report. However, its validity depends on a good understanding of the value of travel time savings, which in itself is a non-market good with a monetary valuation derived from studies of surrogate market behaviour.

2.2.3.3 Hedonic Pricing

The surrogate market can be inferred from the prices of freely traded goods which are to a varying extent influenced by the environmental effect. This technique has been termed "hedonic pricing" and conceptually it is similar to facilities exclusion. In the case of traffic noise, most of the previous published research has used this method, exploring the influence of exposure to traffic noise on residential property values. Hedonic pricing is one of the main focuses of this study and is reviewed in Section 2.3 below.

2.2.4 Hypothetical Market Methods

These methods hypothesise a market by enlisting individuals' responses to some form of questioning. The terms used to describe hypothetical market methods are contingent valuation (CVM) and stated preference (SP). SP and CVM are similar approaches; stated preference is the term developed in the technical literature on valuation of travel time savings and other aspects of travel choice, whereas contingent valuation has its roots in other fields of market research. The term contingent valuation (CVM) has become the most accepted and is used in the remainder of this report.

The basic premise of CVM is that either there is no real world market in which individuals would be able to exercise the choices presented or that the market is inaccessible to the survey agency. The inaccessibility stems from difficulties in identifying those in the market or because of confounding factors which obscure the choices under study. In the absence of an actual market, CVM presents survey respondents with hypothetical choices which include market and non-market attributes. Valuations of the non-market attributes are then inferred by analysis of the survey responses. An important requirement for a successful CVM study is that the choices offered are fully understood by respondents and achieve sufficient realism for the results to be meaningful.

There are a number of ways in which CVM experiments can be designed and these fall into two main groups. The first has been called "transfer pricing", also referred to as a "bidding game" approach, and was the method most commonly discussed in the early literature on CV methods for non-market valuation of environmental quality and wildlife preservation. It aims to establish the level of payment required to make the respondent change his or her mind between one option and another.

The second variant involves discrete choice ranking or rating questionnaires. It is discussed under the body of literature on stated preference methods, which have been widely used for transport choice modelling. The questionnaire will typically face respondents with a number of choices each of which have a mixture of price and non-price attributes. The respondent is asked to rank or rate the choices and the valuations of the non-price attributes are inferred statistically from an analysis of the responses received.

CVM is one of the main focuses of this study and is discussed in more detail in Section 2.4.

2.2.5 Dose/Response Methods

The third basic method for valuing non-market goods is to identify the physical response of the non-market attribute to the influence, or dose, being applied, and then to quantify a monetary value for the response by applying a cost per unit of the dose. The method has generally been applied in situations where there is an adverse effect from the influencing factor, and the relationship between damages caused and level of the dose applied is described as the "damage function".

An example is health damages through exposure to a pollutant. This involves establishing the statistical epidemiological link between "doses" of pollutant and a "response" such as ill-health, hence the name. Another example would be to find a dose-response relationship between air pollution and the chemical erosion of building surfaces.

The valuation of damages can be approached in a variety of ways. If the damages are to individuals and are of a form that is clearly perceived, then one of the willingness-to-pay for prevention or willingness-to-accept compensation methods may be appropriate, such as HPM or CVM. Other methods of establishing unit damage costs are through market prices of measures to prevent or mitigate the damage caused, or to replace the lost or damaged asset where this is possible.

In the case of valuing the social cost of noise, the dose-response relationship has been widely investigated with respect to an annoyance response (*e.g.* Langdon 1976, Kryter 1985, Schultz 1978). However a previous review of the subject by the OECD (1983) found that the physical effects on health and the ensuing costs of medical care, lost output and individual loss of enjoyment of life were not well understood. While noise was suspected of causing stress and eventually contributing to cardiovascular disease, its exact medical impacts had not been quantified. Expenditure on somnifiers (sleeping pills) and calming medicines was found to increase in noisy environments, but it was not clear what portion of these costs were attributable to noise as opposed to other environmental factors associated with these environments.

As the main disbenefit from traffic noise appears to be disturbance rather than measurable health damage, a dose/response valuation method applied to health damages would not be sufficient on its own to obtain a monetary value for the social cost of noise. It is not a focus of the project and is not pursued further in the context of traffic noise.

Dose/response methods have also been used to value the effects of air pollution from road vehicle exhaust and evaporative emissions, particularly in recent years. Medical research has discovered and, to some extent quantified, the carcinogenic effects of certain polycyclic aromatic hydrocarbon compounds and particulates, and the respiratory problems caused directly by volatile organic compounds and indirectly as tropospheric ozone precursors. This has allowed the estimation of unit risk factors for specific compounds and statistical estimates of marginal increases in morbidity and mortality.

Human health costs of air pollution from motor vehicle sources are not as readily perceived as are the effects of traffic noise. While visible smoke, odours and haze are perceptible effects of vehicle pollution, other pollutants such as carbon monoxide and the compounds present in trace concentrations are invisible and odourless. Also, traffic levels at which air pollution effects become perceptible are below those at which noise annoyance is first perceived.

2.2.6 Values Established through Expert Opinion and Political Weighting

This method does not attempt to directly study market behaviour of the population or quantify the dose and response to the environmental effect. It works at a larger scale using consultative and political processes to arrive at an agreed final course of action. Costed and non-costed attributes are given weightings in reaching a decision and a relative value, whether or not this has been made explicit. The process used in New Zealand to obtain resource consents under the Resource Management Act is of this type. Evidence is presented on various aspects of a proposed course of action and a decision is reached in which some degree of environmental modification may be accepted and some degree of mitigation or protection required.

2.3 Hedonic Pricing Method

2.3.1 General Form

Hedonic price theory evolved from goods-attribute theory (Lancaster 1966), and the trade-off theory of residential location. Rosen (1974) provided a good review on the background to the method.

Hedonic pricing combines theories of consumer choice with respect to commodities and locations, expressing property values as a function of housing preferences, accessibility, residential density and social agglomeration. The selling price of a house (V) is denoted as a function (Z_1, Z_2, Z_3 ... Z_n) of these various attributes. Thus spatial price variations may be used to estimate the demand for public goods (or public bads, such as traffic noise) that may emanate from a transport infrastructure. Some form of multivariate analysis is required to identify the individual effect of each of the attributes. The common approach has been multiple linear regression analysis of the individual housing attributes, including various indices of exposure to a local transport facility (eg. a main road), as the independent variables against the sale price or rental value of each house as the dependent variable.

While the HPM is a general technique for inferring monetary values of non-marketed goods from consumer behaviour, in practice almost all applications of the method to the proximity effects of traffic have involved the examination of factors influencing choice of housing location and house prices. Typically these factors have encompassed characteristics of the property and the neighbourhood including environmental attributes such as the levels of traffic noise, as noted by Hopkinson *et al* (1991). A smaller number of studies have considered the choice of housing location and air pollution.

2.3.2 Difficulties with the Hedonic Pricing Method

The hedonic pricing approach to valuing the cost of non-market goods has been subject to increasing scrutiny. Nelson (1982) reviewed evidence on the applicability of hedonic pricing techniques to traffic noise exposure and this remains one of the better concise reviews of the method.

Points made by Nelson and others regarding assumptions and practical application of hedonic pricing were:

- Imperfections in the housing market - restrictions on mobility, supply constraints, lack of objective information among buyers will all influence purchasing behaviour and may severely limit the range of real choice in any one purchase; the generally high transaction costs involved in house purchase in itself implies that not all people in this market are trading at the margins.

- There should be a sufficient range in the environmental attribute (such as traffic noise exposure) to allow buyers a real choice of a noisier or quieter location.

- Differences in individual preferences for a quieter or noisier environment can be expected, and these differences will not necessarily be revealed in a HP analysis.

- The attributes affecting house price have to be identified and measured; as the factors are likely to be numerous the data requirements are high and the important attributes have somehow to be distinguished from the less important ones. The attributes will very often be inter-dependent, giving problems of multi-collinearity in the multivariate analysis.

- There are various practical problems in data acquisition; measurement of traffic noise or other environmental effects may be difficult and/or costly to achieve in practice for a large sample of properties; the data cannot be spread over too long a time period because of possible changes in conditions at the sites being measured, but a short period may yield insufficient data.

- If the aim is to identify the effect of one aspect of road traffic, such as noise, then care must be taken to control for other environmental effects.

- Hedonic pricing based on housing prices will yield a value for traffic proximity effect which capitalises the perceived future time stream of these effects; but the analysis will not necessarily reveal the time horizon and the time preferences of house buyers.

- Estimates of value from hedonic pricing only capture perceived effects; if some effects are unperceived such as health impacts of air pollution, then hedonic pricing may undervalue social costs.

These actual or potential problems are discussed further below:

2.3.2.1 Market Imperfections

Barde and Alexandre (1987) pointed out that many financial social and cultural constraints prevent people from changing houses and location. They termed the "freedom to move" assumption as the "consumer sovereignty hypothesis" which assumes that individuals have the opportunity to buy more or less "quiet" on the housing market.

Nelson (1982) also noted that hedonic pricing assumes residents are free to move from one location to another to increase their utility and posed the question "Are transaction costs in the housing market so large that residential mobility is constrained in a significant way and price differentials therefore understate the true social cost of noise?". Nelson noted that in the U.S. about 20% of the households changed residence each year, and 40% of households relocated within four years. He also indicated that while the higher socio-economic groups had the financial resources to cover transaction/re-location monetary costs, they also valued their time more highly and thus may have incurred a similar level of overall disruption when re-locating as did lower income groups.

We have found no definitive criticism in this literature review which would invalidate the hedonic pricing method on this point of residential mobility. The rate of household relocation noted by Nelson appears to us to be generally similar to the situation in New Zealand. This degree of mobility should allow the effects of any new road facility to be reflected in property transaction costs within a few years. It appears to us unlikely that traffic noise would constitute a primary reason for moving house but, once a decision to move has been made, traffic proximity can enter as one of the choice variables of a new location.

Possibly of more importance than the degree of residential mobility is the true range of choice available to the prospective buyer given a number of self-imposed or externally imposed constraints which may limit the candidate properties. As the options are reduced to a small number, if traffic exposure is not one of the major choice variables, then it may become increasingly difficult to isolate the traffic proximity effect from other determinants of choice.

2.3.2.2 Range of Traffic Noise Exposure

The second assumption is that the attribute being valued is a localised pollutant. If traffic noise were an ubiquitous public bad, the opportunities to re-locate to avoid noise effects would be limited. Traffic noise does, however, vary according to traffic densities and the principles governing acoustic propagation. A report on estimating traffic noise in populated areas, Royds Garden (1992) predicted the following distribution of persons exposed to traffic noise, in a sample urban area (Table 1).

Table 1. Estimated Percentage of Population Exposed to Various Levels of Traffic Noise.

Noise Level 18h L_{10} dBA	Percentage of Population Exposed
> 74	0.3
70 - 74	1.1
65 - 69	4.5
60 - 64	8.6
< 60	85.5

Source: Royds Garden (1992)

These figures show that noise levels likely to lead to high levels of annoyance (which from our experience is above 65 dBA) are likely to affect only a relatively small proportion of the population. This suggests to us that traffic noise is sufficiently localised to allow individuals to choose an "optimal level of quiet".

However, we also infer from these data that a large proportion of the population experience 18h L_{10} noise levels of below 60 dBA. If their housing choice range is confined to properties below this level of noise exposure, the instances where they face a real trade-off between a significantly increased or decreased level of traffic noise and other housing attributes may be quite limited. Thus we conclude that house sale prices from areas exposed to background noise levels will tend to dominate the sample unless steps are taken to stratify the data so that different ranges of noise exposure are more or less equally represented.

2.3.2.3 Differences in Individual Preferences

Hedonic pricing studies result in averaged values of the disutility of traffic over the sample of properties in the study. However, not all individuals will have similar preferences for a quieter or noisier environment. Barde and Alexandre (1987) drew attention to this "similarity of utility functions" as an important factor; the assumption being that all individuals attach the same value to an attribute which determines the value of their house. They noted that, in the case of noise, individual valuations of annoyance were almost certainly not the same. Not only would valuations vary, but so too would perceptions of what levels of noise were annoying.

We infer then that whereas a sufficiently diverse sampling will encompass the range of individual preferences, the consequence is that the hedonic pricing studies provide no information on the distribution of individual valuations or how these may be correlated with residential location, or individual and household characteristics.

A similar problem arises in revealed preference studies of the value of travel time savings which are similar to hedonic pricing in nature. MVA (1987) have described this as a "self selectivity" effect. They suggested that individuals who place a high value on a particular choice attribute tend to make choices which provide more of that attribute.

We would thus expect people who place a high value on quiet to choose to live in quieter areas, and the extent to which their preferences are captured in an hedonic price study to depend in part upon the basis for sample selection. If those who place a high value on quiet are not represented to any measurable extent in areas where traffic noise disturbance is above the background threshold, then these people will be entirely missed in an hedonic pricing study. If a value of noise derived from such a study is then later applied to a situation, for example a rural by-pass, where people who place a particularly high value on quiet are located, the result will be an inappropriate and misleading measure of disturbance.

2.3.2.4 Measurement of the Disturbance Effect

A number of traffic noise measures have been used as indicators of the disturbance caused by road traffic. Nelson (1982) discussed the relative merits and approximate relationships between the measures used in U.S. studies, covering the energy mean sound level (L_{eq}), the day-night average sound level (L_{dn}), Noise Pollution Level (NPL) and Traffic Noise Index (TNI). These various measures each attempt to summarise the noise disturbance over a period of time and over the typical band of frequencies of traffic noise generation. We note that in the U.K., Australia and New Zealand the 18 hour L_{10} A-weighted dB level is the basis for traffic noise prediction models, although L_{eq} is also used extensively.

Individual variability in the reaction and susceptibility to noise will always remain a problem for researchers seeking to define improved measurement indices. However, without entering into the long-standing debates that have taken place regarding the suitability of various measurement indicators, we suggest that the widely accepted 18 hour L_{10} noise level has been the subject of much international research and analysis and is as good an indicator as any of traffic noise disturbance.

We note that a related problem lies in the degree of mitigation cost that may have been invested in properties to combat environmental effects such as traffic noise. As noise measurements and model predictions are almost always external, either at the property boundary or building facade, an investment in sound insulation, such as double glazing, may easily be missed in the collection of data although this may influence the property price.

2.3.2.5 Number and Choice of Independent Variables

Nelson (1982) observed that the number of housing characteristics used as explanatory variables in hedonic pricing studies ranged from a few to over a dozen. We note that where studies are concentrated on a specific geographic area, it may be unnecessary to include any independent variables other than housing attributes and those related to the exposure to road traffic. However, some studies have pooled data from several geographic areas and in such cases a number of additional variables have to be included to take account of other influences distinguishing different suburbs within an urban area, or between urban areas in different parts of the country. This increases the data pool but further complicates the regression analysis.

2.3.2.6 Data Quality and Measurement

Data quality in hedonic pricing studies is an important factor. Williams (1991) noted that the data must be timely, representative and available. For example traffic noise data should be representative of the year in which the house sales data were collected as well as being measured over a sufficiently long period to be representative of traffic levels. This was because disamenity levels may have risen generally (or fallen in the case of corrective actions) over the study period compared to the time period from which the sample was drawn.

We note that actual measurements of the noise levels or other environmental effects experienced by residences may not be practicable, or may be costly, to gather. Calculated values from mathematical models of traffic noise, or proxies such as distance measures could be considered as alternatives to actual measurement. This has the advantage of reducing data collection costs and calculated values from a well calibrated model may even be preferable to site measurements if the latter cannot be made over a sufficiently long period to be representative of conditions. However, any method for the calculation of environmental effects ideally should be validated by comparison against a sample of actual measurements.

2.3.2.7 Separation of Environmental Effects

In the literature reviewed, the aim of studies has generally been to value environmental effects of traffic individually. Most studies have been of road traffic noise, in which case it has been found necessary to include or control for other environmental attributes.

Williams (1991) and Nelson (1982) both emphasised the need to include or control for attributes such as air pollution, when attempting to identify the costs of noise disturbance from traffic. They showed that additional explanatory variables, such as air pollution level, should either be included in the multivariate analysis or else be controlled by ensuring uniformity over the sample for this characteristic. Nelson (1992) noted that where more than one form of environmental impact was included in the data analysis, there was a high chance of multi-collinearity. In such cases, where effects other than noise were omitted, the resulting regression coefficients against noise were likely to be biased because of the omitted correlated variables.

We suggest that this problem of collinearity may be avoided by treating the disamenity of traffic as a single variable, using traffic noise as the indicator of measurement. The results, of course, will be valid only for situations in which other environmental effects such as air pollution and visual impact are well correlated with traffic noise disturbance over the sample and the resulting values will be applicable only to such situations. However, this could well cover the general range of traffic noise disturbance to residential development.

The proposition that traffic noise alone is an effective metric for the disutility of traffic streams passing by a residential property also needs to be examined. When traffic volumes fall below about 2500 vehicles/day, traffic noise levels at the building facade for typical New Zealand residential development fall to the daytime background level (in the range 50 to 55 dBA). However, residents are known to be disturbed by traffic volumes below this level. For example, Brindle (1989) citing various Australian studies, suggested that a "tolerable limit" for daily traffic volume in a street with frontage residential development lies between 1,000 and 3,000 vehicles/day and suggested that environmental acceptability should be achieved if traffic levels are 1,500 vehicles/day or below. We draw the conclusion that at traffic levels between 1,500 and 2,500 vehicles/day, there is some degree of disturbance from traffic which is not adequately measured by traffic noise.

2.3.2.8 Capitalisation of Future Environmental Costs

The value of traffic noise disturbance emerging from hedonic pricing studies is a dollar value which can be expressed as a percentage of the property's market value. Inherently, the ongoing traffic disturbance affecting the property has been capitalised into a present value. If there is a desire to convert this capital value into an equivalent cost per unit of traffic flow, then some interpretation is required of how the hedonic price takes account of future levels of traffic disturbance.

Pearce and Markandya (1989) noted that in order to infer annual benefits from house price data, there is a need to know the annual return on property, as well as rates of taxation applying to the property and to the individual. This was on the basis that the discounted present value of rents net of tax has to equal the property value. Additionally, individual expectations of future pollution levels had to be factored into the calculation. If future pollution was expected to generally decrease, then there would need to be a general increase in property value than if pollution levels were to remain the same. Abelson and Markandya (1985) considered the problem in more detail, reaching the conclusion that the standard regression procedures employed in such studies were more likely to lead to an underestimate of the true hedonic capital price because of failure to adequately consider future environmental changes.

In the Victoria Transport Externalities Study Nairn *et al* (1994), an hedonic price for noise based on capitalised property values was *annualised through the use of a perpetuity factor, with the interest/discount rate assumed to be 5%.* No further basis was given for this choice. By comparison, on the New Zealand property market, our general observation indicates annual rental values to be of the order of 5% of the property purchase price. However, as well as the rental value, the housing market is also highly motivated by expectations of capital gain, which would imply a higher discount rate than that inferred merely from the rental value.

The conversion of capitalised values of noise nuisance from hedonic pricing studies into an annualised cost should not be confused with the debate on an appropriate rate of discount when considering the effects of decisions taken today on future generations on matters of environmental quality. Bein *et al* (1994) noted that a number of economists now recommend using a discount rate ranging from four to zero percent for environmental costs and benefits, with some arguing for a negative rate of discount.

2.3.2.9 Environmental Costs not Captured by Hedonic Pricing

Hedonic pricing studies capture only those environmental costs which are taken into account, consciously or subconsciously, in property transactions. Whether these completely capture individual perceptions of environmental effects and represent a true willingness-to-pay for perceived environmental quality is unclear, but this is a condition of acceptance of hedonic pricing study results. However, there is a further concern that individual perceptions do not necessarily capture the total social costs of environmental impacts.

For noise, it seems likely to us that perceived disturbance will cover the majority if not all of the costs of traffic noise on residential activity. Similarly, all visual impacts depend upon perception and can therefore be considered to be captured in willingness-to-pay studies. However, for air pollution there is mounting evidence of significant health damages from inhalable particulates and polycyclic aromatic hydrocarbons which are most probably not perceived at all, or only in part. The situation may of course change depending on the level of awareness among the general public of these possible health risks.

As this study has confined itself to traffic proximity effects on residential land use, it does not consider environmental costs of traffic proximity to other land uses and to pedestrians. The environmental effects of traffic on road users are only captured in road user costs insofar as they form a component of the value of travel time savings.

2.3.3 Results of Empirical Studies of Hedonic Pricing

Empirical results from a wide range of surveys are available through the literature. Barde and Alexandre (1987) summarised the range of elasticities of house price with respect to noise over a number of hedonic pricing studies (Table 2).

Table 2 Traffic Noise and House Price Elasticities

Study, noise index and area	Unadjusted Depreciation Index (%)	Depreciation Index adjusted to Leq (%)
Allen (1980), L_{10}		
Northern Virginia	0.15	0.15
Tidewater	0.14	0.14
Anderson and Wise (1977), NPL		
North Springfield	0.14	0.18
Towson	0.43	0.54
Four areas	0.25	0.31
Bailey (1977)		
North Springfield	0.30	0.38
Gamble *et al* (1973), NPL		
North Springfield	0.21	0.26
Towson	0.43	0.54
Four areas	0.26	0.32
Hall *et al* (1978), Leq		
Toronto suburbs	1.05	1.05
Langley (1976)		
North Springfield	0.32	0.40
Langley (1980)		
North Springfield	0.40	0.50
Nelson (1978), Ldn		
Washington, DC	0.87	0.88
Palmquist (1980), L10		
Kingsgate	0.48	0.48
N. King County	0.30	0.30
Spokane	0.08	0.08
Vaughan and Huckins (1975), Leq Chicago	0.65	0.65
Average, all studies	-	0.40 (0.26)

Source: Nelson 1982.
Notes: (1) adjusted L_{eq} column is for where studies have used different measures of noise, and these have been adjusted to equivalent L_{eq}
(2) figures in parenthesis are standard deviations.

Table 3 Traffic Noise and House Price Depreciation

Location	% Impact of One Unit Change in L_{eq}
United States:	
North Virginia	0.15
Tidewater	0.14
North Springfield	0.18 - 0.50
Towson	0.54
Washington	0.88
Kingsgate	0.48
North King County	0.30
Spokane	0.08
Chicago	0.65
Canada	
Toronto	1.05
Switzerland	
Basel	1.26

Source: Pearce and Markandya 1989

Table 4 Noise Depreciation Indexes in Selected Countries as Determined in Hedonic Pricing Studies

Country	House Price Reduction per dBA above threshold (%)
France	0.4
Netherlands	0.5
Norway	0.4
Switzerland - Basel	1.26
Canada - Toronto	1.5
United States	
North Virginia	0.15
Chicago	0.65
Washington DC	0.88

Source: BTCE and EPA (1994), citing Quinet (1990) and Streeting (1990)

The results are shown as "noise depreciation index" (NDI), the percentage reduction in house price per additional dBA of traffic noise exposure. The studies showed a range of NDI between 0.08% to 1.05%, with the majority of results falling between 0.3% and 0.6%. Pearce and Markandya, (1989) also summarised prior studies (Table 3). The Canadian and Swiss studies indicated a greater NDI than those from the U.S.A.

The Victoria Transport Externalities Study (BTCE and EPA 1994) summarised reviews by Quinet (1990) and Streeting (1990) as shown in Table 4. These included some additional European studies which showed NDIs of 0.4% to 0.5%.

Overall, if a choice has to made of a single indicative noise depreciation index, then we conclude that a value between 0.4% to 0.5% of property value per dBA of traffic noise exposure above the noise background threshold level represents the current consensus from study results and adoption by overseas agencies in their economic evaluation procedures. This level is a mean over the range of noise exposure, and there is some evidence that the relationship is not linear, the noise depreciation index being greater for higher levels of noise disturbance. There is also a need to select an appropriate threshold background and, typically, 50 dBA has been adopted overseas.

2.3.4 Functional Form of Hedonic Pricing Models

There are many possibilities for the functional form of hedonic pricing models based on property value. Abelson (1979) considered four possibilities in a study of aircraft noise in two Sydney suburbs:

- house price a function of linear variables
- house price a function of a mixture of linear, log and exponential variables
- log of house price a function of linear variables
- log of house price a function of a mixture of log and linear variable

Williams (1991), in a study of the effects of a nearby freeway on property values, tried linear, logarithmic and semi-log functional forms, but found none to be clearly superior in either explanatory power or in avoiding multi-collinearity and heteroskedacity.

Nelson (1982) justified a functional form as follows, based on a semi-logarithmic relationship between annoyance, an index of noise and other independent variables:

$$\text{Property value, } V \quad = \quad b_o.Z^{b1}.A^{b2}.u_2$$

where: A was annoyance = $c_o.e^{(c1.L)}.u_1$;
Z was a set of physical and locational attributes;
L was a noise index; and
u_1 to u_3 were error terms.

This lead to the semi-logarithmic functional form:

$$\ln V \quad = \quad d_o + d_1.\ln(Z) + d_2 L + u_3$$

Nelson (1982) provided summaries of nine property value studies which sought a relationship between property value and traffic noise. The functional forms and explanatory power of the models from these studies are shown in Table 5. The form of the noise index varied among the studies. As all were U.S. based, the noise measure was L_{eq} or NPL, rather than the 18h L_{10} measure which has been favoured in U.K., Australia and N.Z. for traffic noise impact measurement.

These prior studies showed no clear superiority of any one functional form of the regression model, and it appears that selection of appropriate and accurately measurable explanatory variables, particularly with a view to minimising multi-collinearity, is more important in arriving at a good explanatory model.

2.3.5 Selection and Treatment of Independent Variables

As indicated in Table 5, examples of hedonic pricing studies have shown the very wide range of variables that may be introduced to an explanatory model for house price. Variables have been either quantitative, in which case the unit of measurement has been used as the independent variable, or qualitative in which case the attribute has been treated as a dummy variable (=1 if the quality attribute was present, =0 if absent). The variables described features of the property, features of the street or neighbourhood and, depending on the choice of dependent variable, also included aspects of the roadway and traffic.

Another example was Abelson's (1979) study of aircraft noise, in which the independent variables comprised a number of site-descriptive variables and area-descriptive variables including: number of rooms; frontage length; depth of property; construction materials - walls, roof; detached or semi-detached/single or two storey/garage or carport; external condition of the property, year of construction; improvements (accessory buildings, yard improvements); corner and rear access; residential zoning class; amenities in the neighbourhood; social status; and closeness to the sea.

Abelson's study is illustrative of the multifarious attributes of the individual property, street and area which can be brought into a regression analysis. In this particular example, the correlation coefficient r^2 rapidly rose from around 0.25 to 0.50 with the introduction of four variables. Thereon the explanatory power of the model was increased to 0.68 in one case and 0.61 in the other with the introduction of a further 20 or so variables. Even with the relatively small increments in explanatory power of the model the introduction of each variable was found to be significant at a 95% confidence level. Abelson also found that a logarithmic function of house price gave a better correlation than a linear form in his study.

In a study of the influence of the South Eastern freeway in Brisbane on house prices, Williams' (1991) model used the following attributes: house size; lot size; garage spaces; exterior materials; corner lot position; distance to freeway ramp; whether freeway in a cutting or elevated.

Table 5 Model Form in Nine Hedonic Pricing Studies of Noise and Property Value

Study Reference	Dependent Variables	Model Form, Dependent/ Independent Variables	Noise Index	Number of Properties	Regression Correlation R^2
Allen (1980)	floor area, section area, # baths, # fireplaces, house age, house style, basement, materials	linear or log	L10 (best)	206 and 207	0.71
Anderson and Wise (1977)	# rooms, # bathrooms, house age, house design, visibility from road, years of residence in house	log	NPL or log(NPL)	4 sets from 25 to 50	0.51 to 0.65
Bailey (1977)	house design, situation specific factors (very homogenous sample)	log	In(distance)	90	0.89
Gamble *et al* (1974)	# floors, # rooms, # bathrooms, house age, air con, corner lot, exterior constr, design, basement	linear/ linear	NPL	4 sets of 32 to 75	0.48 to 0.78
Hall *et al* (1978)	# rooms, # bathrooms, garage size, swimming pool, time trend	linear/ linear	L_{eq}	21	0.94
Langley (1980)	not comparable method - sale/resale pairs of properties affected to differing degree by a new highway	n/a	distance class	1966	n/a
Nelson (1978)	# rooms, section area, house age, plumbing, aircon, racial mix, riverside location, accessibility index, air pollution index, industrial/commercial land use	log/log	L_{dn}	420 and 456	0.89
Palmquist (1980,81)	area living space, section area, attic area, basement area, garage area, # bathrooms, built-in appliances, house age, distance to park, # fireplaces, trees, floor type, underground services, quality rating	n/a	0	4785 and 2823 and 745	0.68 to 0.90
Vaughan and Huckins (1975)	area of living space, # garages, distance to CBD, distance to lake, sections/block (crowding), broken windows (blight), available recreational land, air pollution level	linear or log/semi-linear	L_{eq}	233	0.55

Source: Studies as cited in column 1

The resulting model gave problems with multi-collinearity of variables and the regression relationship did not achieve a high degree of correlation ($r^2 = 0.32$). This was put down to problems in achieving satisfactory data quality.

Our conclusions are that the number and nature of independent variables included in hedonic pricing studies depends to a large extent on the availability of data on particular housing features. Section area and building floor area have occurred frequently as independent variables, with number of rooms being an alternative or an addition to floor area. Interior features have appeared in several of the models and the inclusion of interior features immediately increases the effort required for data capture as such data is not readily available from external observation or from public records.

2.3.6 Sample Size

The sample size in hedonic pricing studies has varied from the rather small (N=25) up to very large samples (N > 100). Sample size appears to have been conditioned by data availability rather than by specific survey design targets. The degree to which the studies have concentrated their geographic area of coverage has affected the sample size, as the number of property transactions has decreased. There has also been a practical limit on the time period over which samples of transactions have been made due to the difficulty in indexing house prices from one period of time to another.

We observe that indexing of house prices requires quite specific knowledge of the market in the particular part of town being studied, and the house market can be the subject of periods of rapid change, periods of little movement and occasionally periods of decline. The trend in prices can also differ within the market segments, depending on the demand for properties in a certain price range. Consequently, making use of house price data spread over a period of time presents some difficulties.

2.4 Contingent Valuation Method (CVM)

2.4.1 Introduction

2.4.1.1 General Description

The contingent valuation method (CVM) is an expressed or stated preference survey method for eliciting responses from interviewees to questions which involve trade-offs or comparisons between the non-market attributes under study and monetary values. The monetary value is conveyed to the interviewee in a recognisable form which could be a direct payment, a tax, or some other form of benefit or cost with a clear financial value.

A number of general reviews of CVM, its advantages and shortcomings have been made over the past 20 years, including Brookshire *et al* (1976), Cummings *et al* (1986), Mitchell and Carson (1989), Pearce and Markandya (1989) and Hausman (1993).

2.4.1.2 Applications of CVM

Contingent valuation has been widely used in the U.S.A. for determining how much respondents are willing to pay to prevent the destruction of an environmental asset such as wildlife and nature reserves, outdoor activity areas, wilderness areas or for environmental improvements such as cleaner air and less polluted water Hopkinson *et al* (1990).

The theory and application of CVM to environmental assets of this nature has been controversial and has been the subject of critical review, such as Hausman (1993). A number of high profile oil pollution incidents, in particular the *Exxon Valdez,* focused public attention on the risks and consequences of damage to natural ecosystems, and formed a subject for the development and testing of CVM (Desvouges *et al* 1993).

Under the terminology of "stated preference", the method has been extensively used and developed in research on transport behaviour, in particular in relation to choice of transport mode and in the comparative preferences for attributes of transport such as travel time, comfort and reliability.

2.4.1.3 Willingness-to-Pay and Willingness-to-Accept

Depending on the technique employed, respondents are asked questions designed to elicit their willingness to pay (WTP) for a gain or their willingness to accept (WTA) compensation for a loss. The survey technique may be to ask direct questions on WTP/WTA or this is deduced from responses to questions in which respondents are asked to rate or rank two or more options in a structured questionnaire. When asked directly about willingness to pay for or to accept a financial incentive for environmental gain or loss, the technique is often referred to as a "bidding game"; or as "transfer pricing" where the aim is to bid the price up or down to a level at which a distinct switch between choice options is triggered.

In the context of traffic noise, Barde and Alexandre (1987) suggested that questions about WTP and WTA will result in different valuations since the sum of money requested in compensation for noise nuisance is likely to be greater than the willingness to pay for noise reduction, even if willingness to pay does not imply an actual payment. Barde and Alexandre argued that people consider quiet to be a "natural right" for which they should not have to pay, but for which they should be compensated if they suffered any loss of this "right".

Practical use of CVM has therefore shown that quite different results can be anticipated if questions concerning an environmental asset are framed as a WTP for an improvement or as WTA an environmental loss.

2.4.1.4 Extent of Valuation Captured by CVM

Rendel Planning *et al* (1992) state that, because the contingent valuation method asks individuals directly for their full valuation of an environmental asset, it is the only technique which (in theory) fully captures the total economic value of an environmental asset rather than just the individual's own value. They contrast this with techniques which deduce preferences from actual behaviour, such as HPM, from which only the individual's own valuation will be captured.

In the Victorian Transport Externalities Study (BTCE and Victoria EPA, 1994) a strength claimed for CVM is its potential to capture "non-use" values which revealed preference methods would miss. There is some variation in what is construed as a "non-use" value.

Mostly, it separates values associated with physical consumption or use of a good or service compared with satisfaction obtained from remote enjoyment or knowledge that the asset is being preserved. Non-use value is sometimes termed "passive consumption" and includes (BTCE and Victoria EPA 1994):

- Option value - retaining the option to use the good or asset at a later date;
- Existence value - of the comfort that the asset still exists;
- Vicarious value - indirect consumption such as through TV or other media; and
- Bequest value - the comfort that the asset will remain for future generations.

Claims of comprehensiveness for CVM in capturing the full value of a non-market good must be qualified by the requirement that respondents are fully informed and aware of the effect and costs that their responses to a CV survey imply (see Section 2.3.2.9) and that the questions are understandable and realistic. Where values are not fully perceived, for example long term health damage from undetected trace air pollutants, then respondents will not incorporate them into their valuation. The reverse is also possible, where respondents perceive greater damage than is actually incurred.

2.4.1.5 Public and Professional Acceptance

Hypothetical market survey techniques now have an impressive record of success compared to the great suspicion with which the method was viewed as recently as five years ago. This is in large part due to the more rigorous experimental design which has been developed and which has gone a long way to make hypothetical choices as realistic as possible and to minimise the various biases that the method is prone to attract. The statistical techniques for designing multiple choice questionnaires and statistically analysing the responses received have also advanced considerably.

CVM amounts to much more than simply randomly interviewing householders and asking them how much they would be prepared to pay to, say, reduce traffic noise. A good deal of preparatory study and testing of survey techniques is needed if the results are to be free of the many biases that can adversely affect the method. Unfortunately, there appears to be something of a reaction to CVM developing overseas, where the method has become so popular that it is being applied to all manner of personal and community preference issues. Examples where CV surveys are poorly thought through before they are applied can give the technique a bad name.

CV continues to be questioned on more fundamental grounds, particularly in relation to its use for inferring non-use or existence values for natural assets such as wilderness and endangered species.

2.4.2 Considerations in CVM Survey Design

Fowkes (1991) provided a concise summary of recent developments in stated preference techniques to transport issues, while Pearce and Markyandya (1989) and Mitchell and Carson (1989) gave a good general summary of CV as applied to environmental assets and preferences. The following discussion draws on these sources.

2.4.2.1 Transfer Price Studies

Several of the earlier CV studies reviewed in the literature on non-market valuation have employed what is commonly referred to as the "bidding game" technique. This attempts to establish precise values at which individuals will reveal their WTP for an environmental gain (or WTA an environmental loss). The process has also been referred to as "transfer pricing" in the literature on travel choice, the point of indifference at which a change in decision occurs.

Problems found in the use of the transfer pricing technique in hypothetical market studies are firstly that the artificiality of the situation is emphasised, and that the subsequent bidding responses may be lead by the response to the starting bid. There is also a good chance that respondents will either refuse to participate or will treat the process as "a game" divorced from reality. The technique can only be practically applied to situations where there is a trade-off between one clear non-market attribute and the measure of monetary value.

Transfer pricing was used extensively in earlier studies, but less so in more recent work and is not recommended as the method to be pursued in this project.

2.4.2.2 Dichotomous and Multiple Choice Questionnaire

CVM now commonly employs either a dichotomous (binary) choice or multiple choice survey framework, using discrete levels of attributes rather than continuous variables.

The method is to present the subject with a series of discrete choices between either two options at a time, asking for an indication of preference, or ranking or rating a number of options. Data analysis generally uses the multinomial logit model, although other possibilities such as multinomial probit model and multinomial logit derivatives such as sequentially structured or nested logit models are also available. The technique has a number of advantages:

- ability to incorporate several attributes in various combinations;
- can deal with qualitative, ordinal and continuous attributes in the same framework;
- minimises "leading questions" in the presentation of the survey;
- compared with HPM, it is easier to control for attributes not required in the survey;
- is consistent with the micro-economic theory of consumer choice; and
- is relatively straightforward in the statistical methods employed.

2.4.2.3 Choice of Attributes

In deciding what attributes are to be included in a CV survey, one important consideration is that these should not be highly correlated and, if possible, there should be no correlation at all (the attributes then being said to be "orthogonal"). The higher the degree of correlation between attributes, the more difficult it will be to separate their values in the analysis. For example, it would be futile to include both the noise exposure and the distance of the dwelling from the roadway as explanatory variables as the two are so highly correlated.

The number of attributes which can practically be incorporated into a structured choice survey is limited. The fewer the attributes, the fewer questions have to be asked and the easier it is for interviewees to make the choices. One attribute has to be the monetary value or "payment vehicle". It becomes difficult for respondents to deal with any more than five variables and for a new field of enquiry, two or three variables are preferred.

2.4.2.4 Boundary Values

Another consideration in experimental design is the "boundary values" at which the survey subjects become indifferent to the choice between two options. In order to design the survey it is necessary to have some foreknowledge of where these boundary values are likely to lie. Without such knowledge there is a good chance that inappropriate levels of attributes will be chosen and that the experiment will not adequately straddle the various points of indifference between the attributes.

For surveys in which more than two attributes are involved, it is advantageous that for any given pairwise choice, no more than two attributes are allowed to differ. This ensures that the boundary values anticipated by foreknowledge from prior studies or pilot surveys are designed into the survey and are not some unknown function of a third variable. It also allows irrational responses to be more readily identified.

2.4.2.5 Dealing with Irrational Responses

It is important to be able to identify irrational responses so that these can be excluded from the analysis where it is appropriate to do so. These will include respondents who have "taken a position" on a particular environmental attribute and claim that no amount would cause them to compromise a standard or their position. There are also those who have misunderstood the questions; and those who are deliberately trying to bias the results. Fowkes (1991) suggested that for the first group of irrational respondents, even though they may value the attribute very highly, in practice they will not be able to afford to pay the indicated high amount and so are effectively refusing either of the alternatives offered. However, Fowkes also emphasised the importance that the number of such refusals be identified, as this may indicate a demand for some form of performance criterion for the environmental quality.

We conclude that exclusion of "irrational" data from CV surveys is a source of some debate, so this matter must be handled with care.

2.4.3 Biases in Contingent Valuation Surveys

Problems and practical considerations in applying contingent valuation methods have been recognised for many years. The literature discusses the various biases that can infiltrate the design and execution of a CV survey, and other problems stemming from the "unreality" of the choice contexts offered to those participating. A variety of terminology for the various biases has arisen over time, and these are summarised below:

- Respondent Bias - associated with the conscious or unconscious feelings and understanding of the survey respondents, including hypothetical bias, strategic bias and refusal to participate or "zero bid" responses.

- Information Bias - associated with the information provided during the survey application and the prior knowledge of the respondent. This includes the framing and sequencing of the questionnaire including the starting point of a series of questions which anchors the respondent for the remainder of the survey, bias associated with the range of responses suggested by the questionnaire and form of scale presents, and the effect of sequencing of questions.

- Vehicle Bias - bias associated with the payment "vehicle", the means by which non-market attributes are brought into a framework of comparison with a money value or a commodity with a clear value in the market.

- Aggregation Bias - where a combined CVM study of several non-market goods shows a different, normally lower, valuation than the combined WTP from studies of each good individually.

The problems of these various biases are discussed below:

2.4.3.1 Respondent Bias

There are various ways in which interviewees may consciously or unconsciously introduce bias into their responses to CVM questions. These may originate from:

- genuine misunderstanding of the question, or from difficulty in relating the question to their everyday experience, or from a lack of incentive to fully consider the values before responding (hypothetical bias);

- from a desire to influence the result of the survey by giving an answer designed to achieve a certain outcome (strategic bias); or

- from a disagreement in principle with the concept of monetary valuation or the survey method (refusal and zero bid response).

2.4.3.2 Strategic Bias

Brookshire *et al* (1976) argued that individuals have strong incentives to strategically bias the answers to questions designed to reveal their preferences for public goods. Pearce and Markandya (1989) discuss methods for testing for strategic bias and noted that laboratory experiments and CVM studies showed little or no evidence of strategic bias. Diamond and Hausman (1993) note that expressing a concern in dollar terms may be different from a genuine willingness to pay the same number of dollars. Intuitively, certain lines of questioning seem more likely to induce a strategic response, for example questions which equate WTP with some form of levy or tax imposition, as opposed to questions which imply a more voluntary form of payment.

2.4.3.3 Hypothetical Bias

This is a fundamental concern in CVM and is most pointedly described by the maxim "ask a (hypothetical) silly question and you get a (hypothetical) silly answer". Interviewees may find the hypothetical situation particularly hard to grasp. It is therefore important that any choice context put to survey respondents be one with which they are familiar and with which they can identify.

Thayer (1981) put forward the idea of using site substitution analysis to counter the effect of hypothetical bias. For example, apart from asking the respondents to value the particular environmental attribute, other questions could be asked which would indicate alternative plans that would satisfy their demand for an environmental goal. The responses to these alternative plans (such as travel, recreation, etc.) could then be valued from market price data and used to check the validity of their bidding game response.

Pearce and Markandya (1989) describe other forms of back-to-back study where CVM and actual payments are compared (removal of hunting licenses - Bishop *et al* 1983), or where the choice context is varied between WTP and WTA (doses of an unpleasant but harmless liquid - Coursey *et al* 1985). In each case, some evidence of hypothetical bias was detected which, in the second case, reduced as the respondents became more familiar with the actual experience involved.

In the case of traffic noise, respondents may have few ideas about the means and costs of reducing noise, may not be fully aware of the real damage they have to suffer, and hence be largely ignorant of what suitable compensation would be. Offering levels of noise exposure in decibels will have little or no meaning to most householders, whereas a qualitative description of the traffic conditions may be more readily associated with the proximity disturbance from noise and other effects.

There have been efforts to engender realism to surveys of personal response to environmental effects of traffic by attempting to physically simulate the environmental changes in a controlled laboratory setting, for example Rosman (1978). Use of sketches and photographs to convey information is another option. Baughan and Savil (1994) describe examples of these approaches.

2.4.3.4 Refusals, Excessive and Zero Bids

A recognised problem in CVM is how to deal with respondents who choose zero when asked a WTP question, or who refuse to participate or give an extreme response. Zero bids may be genuine zero or near-zero values, or may be indicative of a lack of understanding of the question.

Zero bids may also be protest bids in the same group as refusal to participate, either because of an aversion to placing a money value on environmental quality, or a reluctance to reveal any willingness to pay for what they may deem a natural "right" (a form of respondent bias). For example, in the Third London Airport Study, 47% of respondents stated they were not prepared to pay anything to reduce noise and, in a study of the social cost of noise around Paris-Orly airport, 77% of respondents stated they would not accept any compensation for noise (Barde and Alexandre, 1987).

2.4.3.5 Information Bias

Informational bias implies that the nature of the questions and framework within which answers are elicited will influence the responses received. The questions themselves convey information which may be new to the respondent or at variance with his or her past experience. Where a payment card approach is used, the range of answers and form of scaling immediately imposes a frame of value in the mind of the respondent.

Rowe *et al* (1996) considered the problem of range and centering bias in the design of payment cards, testing four different ranges and centre points in the context of WTP for hazardous waste cleanup. They found that, provided an exponential scale was used for the increments in payments, and provided there was not a problem of truncation in the payment range, then range and centering had no significant effect on response.

One method suggested by Thayer (1981) to test for this bias was to supply two sub-groups of the sample with information which was different but intended to elicit the same response. By testing for significance of the difference between the groups, the effect of informational bias was able to be gauged. Thayer came to the conclusion that informational bias was not a significant determinant of bid behaviour.

The is the possibility that the WTP indicated by a respondent's answer to a series of questions may be biased by the choices offered through the survey medium and the order of questioning. Brookshire *et al* (1976) described "starting point bias", the biasing of responses arising from the starting point in the bidding process, and suggested that the significance of this bias could be tested by varying the starting point for different individuals drawn from a homogenous group of respondents, and comparing the final bids.

This form of bias was later widened in description to "anchoring bias" and "range bias" to describe the wider range of sensitivity of response to the range of choices offered, their scaling and range limits.

There is now an extensive literature on the sensitivity of CVM to the methods used to deliver the questions, usually through some form of payment card that sets out the framework of choices. Examples are Cameron and Huppert (1991) and Rowe *et al* (1996).

The potential for respondents to use their replies to earlier question to anchor their later responses is illustrated by Diamond and Hausman (1993) citing a study by Samples and Hollyer (1990) on the value of preserving whales and seals. People were disposed to value whale preservation higher than for seals. However, the value for seals was lower if the value of whales was asked first and then seals were introduced to the questioning compared with the reverse, with a question on seals being put first. Respondents rationalised their replies to maintain a relativity between their expressed feelings for seals and whales, but this relativity was anchored to whatever value they had established in the first question.

2.4.3.6 Aggregation Bias

Aggregation bias suggests that single issue surveys may not adequately take account of the survey respondents' income constraints; another manifestation of stated willingness to pay differing from actual behaviour. A way of minimising aggregation bias is to survey WTP for the combined environmental states and then to explore how the component environmental attributes contribute to the broader valuation. Another countermeasure is to cross check the survey answers against the income constraints of the respondents, and remove outliers as suggested by Willis and Garrod (1993).

2.4.4 Examples of CVM for Traffic Proximity Effects

While published international literature on contingent valuation studies is increasing, as yet the technique has been used very sparingly in the valuation of the environmental impacts of traffic proximity effects, such as noise and air pollution.

The U.K. Department of Transport (1992) indicated that it was embarking on a programme of research into methods of non-market valuation stating "the Department considers that the greatest early scope for monetary valuation lies in contingent valuation and stated preference methods but that there are practical and theoretical issues which will need to be addressed with care in the development of these methods".

The DoT subsequently commissioned a review of non-market valuation methods (Rendel Planning, 1992) and then an exploratory study into CVM applied to traffic nuisance (Baughan and Savill, 1994). (Note that this exploratory study was unpublished at the time of the pilot surveys described in Section 3 below).

A summary of the conclusions and recommendations from the exploratory study were:

- Designing CV questions for traffic nuisance is more than usually difficult because of the problem of how to describe or simulate the changes being valued.
- Questions might be more realistic if expressed as changes in the effects of traffic rather than measurements of noise or air pollution which have little meaning to the average interviewee.
- Questions about nuisance on a rating scale was potentially very attractive and were tested on a sample of 25 people.
- Interviewees could conceptualise doubling or halving of traffic volumes (better than absolute volume differences).
- About three quarters expressed a willingness to pay for traffic nuisance reduction and appeared to make reasoned judgements from the payment options provided.
- Only 9 out of 25 expressed a willingness to accept compensation for increases in traffic (we note this is possibly a manifestation of the "natural right" viewpoint referred to in 2.4.1.3).
- Answers to questions about WTP for a reduction in traffic nuisance may be influenced by whether there is a practical way for actually implementing the change (if the question appears unrealistic, it is difficult to give a well considered response).
- There were very strong views on the method of payment, influencing factors being: whether a local or national issue; practicality of the collection method; whether interviewees felt that polluters should pay; confidence in money being used for the intended purpose; and whether the payment would be enough to achieve the change. The payment vehicle was thus very important in questionnaire design. It was felt that a more abstract method of payment could remove biases introduced by the payment vehicles suggested.
- Consistency of valuations of, and the relationship between, traffic exposure and traffic nuisance needed to be more fully investigated.

2.5 Comparison of Hedonic Pricing and Contingent Valuation Methods

Although, from the technical literature, there appears to have been no back-to-back direct comparison of contingent valuation against hedonic pricing for valuing the same environmental attribute in the context of road traffic, it is possible to construct some concluding remarks on the comparative usefulness of these two methods.

2.5.1 Hedonic Pricing

Hedonic pricing is an indirect method of assessing the valuation of non-market goods such as traffic noise. It uses a surrogate market (the housing market) as a means of reflecting welfare changes and although it requires considerable input data, it has been used successfully in a number of studies which show some measure of central tendency with respect to defining the effect of traffic noise on house prices. As an indicator of the total disamenity imposed by an adjacent road and traffic stream on residential property, it is probably an underestimate for three reasons: because disamenity occurs at traffic levels below that at which noise nuisance is apparent; because of unperceived damages to residents which therefore are not reflected in the environmental component of house value; and because the value takes account only of the purchaser's preferences rather than the community as a whole.

In summary, the considerable history of such studies provides some consensus for a Noise Depreciation Index (NDI) in the range of 0.4% to 1.0% of property value per dBA of noise exposure over a threshold level. The OECD and Australia have both adopted, as an interim measure, a value of 0.5%, with a threshold in the range of 50 to 55 dBA (24 hour L_{eq}). There is also reason to anticipate some non-linearity in the relationship between depreciation and noise level particularly for a higher value of NDI. For reasons noted above, this valuation is more likely to under rather than overstate the proximity disamenity of road traffic.

2.5.2 Contingent Valuation

Contingent valuation now has a considerable history of use, but very little in the context of environmental effects of road traffic. According to Rendel Planning *et al* (1992), CVM has not been widely applied to traffic noise valuation because the impact of traffic noise is difficult to specify. To use CVM requires either an adequate noise-nuisance quality index relating the magnitude of noise impact to the total disamenity of the road and traffic flow, or an alternative to traffic noise as an indicator of traffic disturbance.

Contingent valuation has very definite advantages over hedonic pricing arising from the ability to control the attributes entering the analysis and from lesser data requirements. Provided care is taken with the survey design and the statistical analysis of the results, there is less risk of inadvertently omitting relevant price attributes, and problems of multi-collinearity of variables can be more readily avoided.

The concerns about the hypothetical nature of CVM for valuing the environmental effects of traffic have lessened after extensive use of the method in other contexts of travel choice behaviour. However, the success of the method still relies on presenting respondents with comprehensible and realistic questions in which the monetary variables have some meaning to the respondents in relation to the environmental attributes, and upon well designed survey and analysis techniques.

3. PILOT SURVEYS

3.1 Introduction

The purpose of this pilot survey stage was to test possible data capture techniques and, to a lesser extent, the analysis approach. It was also useful in allowing the cost of implementing a full survey to be more accurately estimated. While it may be advantageous for the pilot data to eventually form part of the full survey sample, this depended on the success of the pilot stage and the need to revise the data collection methods for a wider survey.

The pilot survey was in two parts: a collection and interpretation of property value data for the hedonic pricing approach; and a contingent valuation study approach by interview survey. The property value data was able to achieve a wider coverage than the interview survey because of the relative ease of obtaining property transaction records from Valuation New Zealand.

There were potential advantages in linking the two surveys by some commonality in the sampling, the CV survey sample being a subset of that for the hedonic pricing study.

3.2 Geographic Focus of Study

It cannot be assumed that the disutility of noise intrusion will be uniform over the population. Further, it is to be expected that residential location will to some extent reflect owner preferences for, and ability to purchase, environmental quality. With this in mind the focus of WTP studies should be aimed at situations which are likely to arise in project evaluation so that the application of results is in a similar context to the research studies.

Two geographical contexts were suggested. The first was a main urban/suburban arterial road which may be considered for widening, with encroachment of traffic closer to residential facades. The second was where a new road may be constructed as a bypass to an urban area, involving a major change in noise exposure to residents previously unaffected by traffic. All else being equal, in the former situation residents may be anticipated to value noise disturbance less highly than in the latter because of their choice of location of residence. The rural resident would be expected to put a higher value on "peace and quiet" than the urban resident alongside an established main road. The first context is the easiest to approach in the pilot survey stage, because of the more controlled and contained data set, and formed the focus of the pilot study.

3.3 Factors Influencing House Prices

The real estate agent's adage on the three factors which most influence property value are "location, location, location". While this may be something of an exaggeration, it must be assumed that house prices will be heavily influenced by locality. It follows that when comparing property values against the possible influences of traffic, a greater level of control of locational variation in property value will be achieved if the sample is concentrated within a recognised locality and not widespread over several residential areas.

Individual street value may also be important but is more difficult to control, as a single street will not provide sufficient transactions to form the basis of analysis and, except in rare circumstances, there will be little variation in traffic volume along a single street.

Other factors unrelated to traffic which can be expected to influence property price are:

- the state of the housing market when the property was sold
- the land use and condition of neighbouring properties
- the useful size of the section, and improvements
- floor area of the property
- the aspect of the site, sunlight and shading
- physical construction, state of exterior and structural repair
- numbers, types and standard of rooms and fittings
- utilities and their condition - power, gas, drainage, water
- ancillary buildings on the property

3.4 Factors Affecting Traffic Disturbance

The aim was to identify the resident's disutility associated with passing traffic. While traffic noise appears from the literature to be the dominant "proximity" influence of traffic, other environmental factors which should be considered are visual intrusion, local air pollution and possibly intimidation (perception of danger). Vibration may be considered as part of the noise disturbance but is likely to be a lower order of magnitude impact in the situation under study.

Visual intrusion involves both the view from the property of the road and the view into the property from the road. In most cases visual screening will act on both. It was desirable that the study should differentiate between properties which were visually screened and those which were visually exposed. However, the fact that a property is visually screened does not mean that it is also acoustically screened.

Pollutant emissions from vehicles increase with traffic volume and congestion so should to some extent be correlated with noise which is similarly related to traffic flow. However, the concentration of air pollutants at the receptor also depends upon the degree of containment of the site, the horizontal component of wind speed and direction and vertical air movement. Air pollutant concentrations are greater under still conditions, particularly when there is temperature inversion, and where the local topography limits air movement. The literature shows the perception of air pollution to be of lesser magnitude than the perception of noise disturbance. In the situations being studied there were no local circumstances such as street canyons which would lead to high concentrations of pollutants. It was concluded that local air pollution would constitute a second order impact and be quite highly correlated with traffic noise.

It can be anticipated that intimidation of householders by the presence of nearby traffic is likely to differ between ages and structures of household, although there is little evidence from the literature of such effects. Households with young children will be particularly sensitive to potential danger. This implies that household type should desirably be included in the surveys.

These factors influencing traffic disturbance are postulated from the technical literature and general experience. Desirably there should be a firmer basis for choosing indicators of disturbance based upon some form of resident survey in the area of the survey.

3.5 Indices of Traffic Disturbance

3.5.1 General Considerations

A suitable index of traffic disutility is needed against which to test a hypothetical market for willingness-to-pay or willingness-to-avoid the proximity of traffic. Previous studies have employed L_{eq}, L_{10} and L_{dn} noise measures, or the log of distance from the road as a surrogate measure. Most surveys have employed direct measurement of noise which has some problems because of the relatively short periods of measurement and failure to correct for traffic changes over preceding years. Attempts to include noise and air quality in regression models of property value appear to have largely failed because of collinearity between the two forms of nuisance. Previous studies seem to have ignored any other possible traffic disamenity effects.

3.5.2 Indicators for Traffic Noise Disturbance

As noise is a principal environmental impact, the recognised measurement statistic of 18 hour L_{10} dBA is the obvious choice as an index of disturbance for traffic noise, at least during the daytime.

The possibilities for measuring or estimating L_{10} traffic noise exposure are:

- one metre in front of the property facade (CRTN method)
- interior of front rooms, allowing for attenuation through windows (open or shut)
- at the centre of the front yard for exposure of outdoor activities to traffic noise

The U.K Department of Transport mathematical model for noise prediction in the "Calculation of Road Traffic Noise" has been validated for use in New Zealand Barnes *et al* (1994). The output from this model, together with known effects of surface reflection from property facades and attenuation through walls and windows, should allow traffic noise exposure to be accurately estimated within the range limits of the model (uninterrupted flows with a minimum of 2,000 veh/18h day). This is probably to be preferred to actual noise measurement which is time consuming, costly and likely to be inaccurate unless conducted over an extended period. However noise measurements will be required to establish the ambient (background) level, which will vary depending on the residential area, and for check measurements to ensure that the modelled traffic noise exposure conforms with observation.

The 18 hour L_{10} dBA level is a measure recognised to be a good indicator of daytime disturbance from traffic noise. However a secondary measure may be needed for night-time exposure to intermittent disturbance from isolated vehicles passing during the night (midnight to 6 am).

3.5.3 Indicators for Visual Screening

Physical features which will affect the degree of visual intrusion caused by traffic comprise:

- physical screening between the dwelling and the road (by vegetation, fencing, walls, ancillary buildings)
- distance from the dwelling frontage to the edge of carriageway
- length of the property frontage abutting the road
- elevation or depression of the property relative to the roadway.

While each of these could be introduced and tested as possible explanatory variables, it may be possible to develop a composite measure of visual intrusion taking each of the above into account. This could be done in the form of some combined rating or more systematically as a measurement of the solid angle subtended at the property facade by the roadway. For example the view of roadway and passing traffic can be considered as a visual strip on average 2.5 metres high (light vehicle height plus an allowance for larger vehicles and street furniture). The solid angle subtended by this strip at the property facade, and the potential visual intrusion, will vary according to the set back from the road subtending a solid angle. For a typical frontage property the potential field of view will be approximately 120° wide with a vertical angle between ground level and about 30° above horizontal.

A visual index of screening could then be set to a maximum of 1.00 for a frontage property with an uninterrupted view of the roadway. A complete visual barrier would correspond to an index value of 0.0. Partial screening would be assessed as the ratio of the solid angle of view of the roadway to the solid angle of the uninterrupted view. The index would also be reduced for properties set further back from the road frontage.

3.5.4 Indicators for Intimidation and Security

Indicators may be needed for intimidation; that is the perceived hazard of the roadway and traffic. This intimidation will be different for people walking on the footpath and for people within the property, so two separate measures may be needed according to the context.

A measure of security of the property boundary can probably be adequately dealt with using a dummy variable. Properties which are unfenced or which have apparently permanently open gateways can be classified as insecure boundaries, while those which are fully fenced and gated can be classified as secure.

3.6 Hedonic Pricing Pilot Survey

3.6.1 Considerations in Sample Selection

As noted by Nelson (1982), most investigators have used small residential areas as a basis for data collection and then attempted to increase the sample by pooling data from different years or across several comparable residential areas. There are dangers in pooling data, where inflationary effects are difficult to monitor accurately, and more particularly the pooling of inconsistent data from several areas. In this study, the initial focus for the pilot survey was to identify sufficiently large contiguous and homogenous areas to provide one or more data sets, so that further pooling could be avoided. However, pooling across different years of property sales would seem to be inevitable, in order to obtain a sufficiently large sample.

Another problem in sample identification revealed from the literature, is an overly large proportion of the sample being close to the background noise level. As is noted below, there tends to be a shortage of residential properties at the higher levels of traffic noise exposure, partly because these high traffic road frontages comprise a minority of the total road property frontage and because other non-residential land use frequently fronts the busier roads. The residential properties which do front onto busier roads also tend to have a larger than average proportion of rental accommodation. There are obvious difficulties in including both rental and owner-occupied properties in the same sample as the motivations for house purchase can be expected to differ between owner occupiers and non-resident landlords.

Nelson (1982) also noted the need to control for other adverse or beneficial effects of highways, and other locational attributes of the property, which may not be specifically included in the cost model. This point was considered in selecting the pilot sample by avoiding parts of the residential neighbourhood which had features such as: close walking distance to neighbourhood shops; adjacent to non-residential land use; or close to power pylons.

3.6.2 The Sample Area

For the pilot survey it was decided to sample properties from a single, and as far as possible homogenous, neighbourhood so that the number of explanatory variables could be contained. Homogeneity was sought in regard to the quality of housing and prevailing size of residential sections, general outlook from the properties, proximity of workplaces and shopping centres, coverage by school zones, and identity as part of a common residential area.

For ease of access, sites on the Auckland isthmus were considered for the pilot survey. Five areas were selected from a study of street maps and general knowledge of the area, and these were then inspected in the field for suitability. The areas considered were:

1. South Mount Eden - bordered by Balmoral, Dominion, Mount Eden and Landscape Roads;

2. Sandringham - bordered by Balmoral, Dominion, Sandringham and Mount Albert Roads;

3. Blockhouse Bay/New Windsor - bordered by Tiverton, New Windsor, Maioro, Richardson, White Swan, Donovan and Blockhouse Bay Roads;

4. Hillsborough - bordered by Hillsborough Road, Richardson Road, the Southwestern Motorway and Keith Hay Park; and

5. Westmere - bounded by Garnet Road, West End Road, Wellpark Ave and Warnock Street.

Of the five areas, number 3 was selected for the following reasons:

- A good representation of street types from primary urban roads through to "no exit" streets, with an accompanying wide range of traffic volumes.
- Relatively homogenous in housing quality and similar outlook (most properties have a view from either front or rear, all views are over the local area).
- Properties on the main roads were mainly residential and appeared to be mostly owner-occupied (in other areas residential properties on main road frontages were fewer and a considerable proportion were obviously rental accommodation).
- A relatively large area, giving the prospect of a good number of recent housing sales.
- A mature stable area, fully developed with a good mix of household types and no pockets of urban decay.
- No major shopping centres in close proximity, so distances to shopping centres relatively equal for all properties.
- With the exception of an electrical switchyard and high-tension lines in the extreme east corner (which was avoided in the sampling), commercial land use was limited to small neighbourhood shops with no industrial use.

3.6.3 Capture of Valuation Data

All streets within the area were generally categorised into the following four groups:

- main roads
- secondary roads
- distributor roads
- local roads
- no exit streets

The Consultant's building valuer was requested to search the Valuation New Zealand records for any transactions of properties in the area over the period 1988 to 1992. It was felt that this relatively long period could be justified in view of the very flat house price market which prevailed in New Zealand over the period. Sales later than 1992 were not included as property values started to move up quite rapidly after that time. In this selection it was hoped to avoid the analytical problems encountered by several of the overseas studies which were carried out in periods of high property value inflation. A target of 100 to 200 properties was sought, amounting to $1,000 expenditure on search fees. For an estimated 5,000 properties in the area and a "rule-of-thumb" average time between sales of 5 years, it was expected that the whole area would generate approximately 2,500 transactions within the 1988 to 1992 period.

The Valuation Department search was able to provide the following data on each property:

- street address
- land area (sq m)
- nature of the building (Single unit dwellings only included)
- date of sale and net price paid (chattels indicated separately)
- government valuation(s), land and capital value
- approximate date of construction
- general zoning (residential)
- floor area (sq m)
- numbers of units (1 only selected)
- wall materials (brick/weatherboard)
- wall condition (good/average)
- roof material (steel or galv. iron, tile, fibre cement, mixed)
- roof condition (good, average)

Only class 110 transactions were included in the search. These are sales which are understood to be "arms-length", which would reflect the market value of the property. Other sales could be family transactions or involve leasehold arrangements.

The number of useful sales was fewer than expected, the search yielding 256 transactions for the whole area over the 1988 to 1992 period (about 4.5 years), that is 1 sale for every 100 properties per year or 1/10th of the initial estimate. A full listing of the sample data and a copy of a typical Valuation Department property record is included in the Appendix.

3.6.4 Indexing of Transaction Prices

Even though the property market had not experienced rapid changes in value over the period, a method was still required to adjust values to a common base. Valuation New Zealand publishes "Urban Property Sales Statistics" half yearly, and this provided the most accessible and consistent means of price indexing.

The number of sales and the average selling price were recorded for June and December six-monthly periods by Local Authority, and for the country as a whole. Sales numbers and prices were also subdivided by age category of the property and by local authority, which provided some additional information on the relative values within the housing market. Unfortunately the statistics did not classify sales by price, so there was no means of tracking whether changes in average selling price were a result of differences in the proportion of sales between different price brackets. The pilot survey area was part of Auckland City, which covered all of the Auckland isthmus, so differences between different suburban areas were obscured.

3.6.5 Data Collection on Site

Having obtained a sample of properties from the Valuation New Zealand records, the next step was to view the properties and establish whether they had any unusual features which should disqualify them from the sample and then, for those which passed this screening, obtain further data on the properties by visual inspection from the roadside and from aerial photomapping.

Factors which were taken to disqualify properties from further inclusion in the sample were:

- corner sections and sections opposite a T-intersection
- change in land use between adjoining or opposite properties
- other unusual factors - such as proximity to power pylons

For the pilot survey, multiple unit properties and rear section properties were grouped separately from single unit street frontage properties which formed the main focus of study.

Aerial mapping was available at a mixture of 1:1000 and 1:500 scales from Auckland City Council. This allowed set-back distances and other leading dimensional data to be scaled off the plans, either prior to or after site inspection, including:

- road width, verge/footpath width
- length of street frontage
- mid-block/end of block/opposite minor road junction
- set-back of main building from front boundary
- compass direction of building face
- proximity to adjacent buildings on each side (side yard widths)
- length of front facing facade

The data collection on site comprised all observable physical features which could reasonably be expected to influence the property value, as follows:

- off-street parking (yes/no)
- presence of visual screening along side boundaries and adjacent property front boundaries
- elevation of property with respect to the road
- form and percentage of visual screening along front boundary
- form and percentage of acoustic screening along front boundary
- physical security of the site (for keeping young children and pets within the property boundary)
- confirm the building materials as reported by Valuation Dept
- general building style
- single or multiple level dwelling
- development of basement area
- ancillary buildings and facilities (garage/workshop, deck, pool etc)
- use of front yard (ornamental/outdoor living/utility)
- general external condition of building, as viewed
- general external condition of the section, as viewed

- estimated facing wall area of occupied part of building
- estimated percentage window area facing the road
- type of windows (sash/casement, wood/alloy frames)
- main entranceway at front or side/rear of building
- streetlight directly in front of property

Some of these features required estimates of size or distance by the observer. To maintain consistency, the selected properties were photographed, allowing some measurements and detailed observation to be made or checked in the office. A copy of the prototype survey form for a residential property is included in the appendix.

3.6.6 Traffic Characteristics of the Site

For local and no-exit streets, the daily traffic flow was estimated on the basis of an assumed trip generation per household using transportation study surveys. (This should be confirmed by laying a traffic counter over the end of selected residential no-exit streets in a full survey). For other streets, traffic volume counts were either obtained from local authority records or estimated from short period counts carried out on site. Short period counts were also required on streets for which there was traffic volume data to identify the classification into types of vehicle.

3.6.7 Proximity to Facilities

Although the pilot survey site was chosen so that the distance to neighbourhood facilities was similar from all properties, in extensions of the study to different areas or for other areas which have less homogeneity, proximity factors may well become important. Distance from the following facilities could possibly influence property value:

- nearest public transport route
- to neighbourhood shops
- main shopping centre
- nearest primary school
- central business district

3.6.8 Analysis Techniques

The role of the pilot survey stage was mainly to test the practicality of the data acquisition methods rather than to provide analytical results. However, some appreciation of the form of analysis of the data was required at this stage and some exploratory regression analysis was performed. Simple linear regression on one or two independent variables was carried out rather than a stepwise analysis involving several variables. A stepwise analysis would test the significance of addition or removal of independent variables to/from the regression equation.

The variables tested were:

Dependent Variables:
- indexed property selling price
- indexed property selling price normalised to price per square metre of floor area
- indexed property selling price adjusted for "street value"
- indexed property selling price normalised and adjusted for "street value"

Independent Variables:
- floor area (sq m)
- section area (sq m)
- estimated facade noise exposure
- index of visual intrusion
- simple distance of building facade from the traffic stream

The notion of "street value" is that the market value of properties is influenced by having an address in a particular street, because the street is considered more or less desirable. Consequently, otherwise identical properties may have a different market value according to their street address.

The total data set, using only mid-block properties (intersections and corners were avoided), was 256 observations. The U.K. CRTN formula, as modified for use in New Zealand, was used to estimate the 18 hour L10 noise level at the property facade. This resulted in noise levels above 55 dBA only for those roads which could be classified as arterial or distributory roads through the area. Local roads, with traffic levels below 2,500 vehicles/day and low percentages of heavy vehicles, did not reach the background level and were excluded from the reduced data set, which then comprised only 39 observations.

3.6.9 Initial Analysis Results

These are shown in Table 6. A simple linear regression of property price (P) against floor area (FA) for the full data set gave the relationship:

$$P = 440.\ FA + 78{,}400 \qquad (R^2 = 0.40, \text{ standard error of FA} = 33.5)$$

Inclusion of section area as a second independent variable did not improve the explanatory power of the model. On the reduced data set, for which noise nuisance would be expected to be experienced, the relationship was similar:

$$P = 336.\ FA + 87{,}600 \qquad (R^2 = 0.41, \text{ standard error of FA} = 65.4)$$

Inclusion of modelled facade noise level into the reduced data set improved the correlation only slightly. However the coefficient against noise was positive, that is property value increased with exposure to increased traffic noise. The standard error of facade noise level was high.

It was suspected that prices could be affected by "street value" so a comparison of area-normalised and indexed prices was made over the complete data set. Some streets have a relatively large number of sales and the area-normalised price was significantly different between streets. This comparison was also made for streets by function (main, secondary, distributor, local, and no exit) but no significant differences were detected on this basis, although this finding must be qualified because of the limited traffic volume data available for the local and no exit streets.

It was decided to test the effect of further normalising the price data by a factor to compensate for street value, this factor varying in the range 0.85 to 1.15. The street value adjustment involved factoring the property value by the ratio of the market value per square metre of floor area for all properties in the street to the market value per square metre for all properties in the sample. When this was done, the regression analysis of price versus floor area gave:

$$P = 615.\,FA + 56{,}400 \quad (R^2 = 0.58, \text{ standard error of } FA = 32.8)$$

This second price adjustment therefore improved the correlation of the simple linear model. Again, this adjusted price normalised against floor area was regressed against noise exposure, but with a complete lack of correlation.

The inclusion of the visual index, either in conjunction with or separate from noise exposure, was similarly unsuccessful in explaining the variation in house prices.

As a final test at this stage, a regression of normalised house price against distance of the facade from the traffic stream was made. Again, no correlation could be detected.

3.6.10 Conclusions from the Pilot Hedonic Pricing Survey

These preliminary results were not particularly encouraging for the application of an hedonic pricing method based on property prices. Apart from the inherent limitations of simply mapping the marginal cost of traffic proximity impact, there is little indication at this stage that the regression analysis will be able to identify an influence of noise level on house price.

Table 6: Preliminary Analysis of the Pilot Hedonic Pricing Survey

Selling Price vs Floor Area
All Data

Regression Statistics	
Multiple R	0.635
R Square	0.403
Adjusted R Square	0.401
Standard Error	28118.59
Observations	256.00

	Coefficients	*Std Error*	*t Stat*
Intercept	80396.28	4942.39	16.27
Floor Area	428.73	32.75	13.09

Selling Price vs Section Area
All Data

Regression Statistics	
Multiple R	0.03
R Square	0.00
Adjusted R Square	0.00
Standard Error	36377.46
Observations	256.00

	Coefficients	*Std Error*	*t Stat*
Intercept	137553.58	8611.31	15.97
Floor Area	4.00	10.00	0.40

Selling Price vs Floor Area and Section Area
All Data

Regression Statistics	
Multiple R	0.635
R Square	0.403
Adjusted R Square	0.399
Standard Error	28161.94
Observations	256.00

	Coefficients	*Std Error*	*t Stat*
Intercept	83248.17	7855.41	10.60
Floor Area	429.89	32.89	13.07
Section Area	-3.63	7.77	-0.47

Selling Price vs Floor Area
Reduced Data

Regression Statistics	
Multiple R	0.645
R Square	0.416
Adjusted R Square	0.401
Standard Error	21933.28
Observations	39.00

	Coefficients	*Std Error*	*t Stat*
Intercept	87564.02	9925.62	8.82
Floor Area	335.77	65.35	5.14

Selling Price vs Floor Area and Noise Level
Reduced Data

Regression Statistics	
Multiple R	0.667
R Square	0.445
Adjusted R Square	0.414
Standard Error	21689.75
Observations	39.00

	Coefficients	*Std Error*	*t Stat*
Intercept	79678.02	11411.50	6.98
Floor Area	335.07	64.63	5.18
Noise Level	886.06	654.00	1.35

Selling Price vs Floor Area, Noise Level, Visual Index
Reduced Data

Regression Statistics	
Multiple R	0.67
R Square	0.45
Adjusted R Square	0.40
Standard Error	21969.53
Observations	39.00

	Coefficients	*Std Error*	*t Stat*
Intercept	80386.92	11800.70	6.81
Floor Area	336.07	65.55	5.13
Noise Level	924.90	675.13	1.37
Visual Index	-5027.21	16860.83	-0.30

Table 6 (contd): Preliminary Analysis of the Pilot Hedonic Pricing Survey

Noise Level vs Visual Index

Reduced Data

Regression Statistics	
Multiple R	0.193
R Square	0.037
Adjusted R Square	0.011
Standard Error	5.35
Observations	39.00

	Coefficients	*Std Error*	*t Stat*
Intercept	7.86	1.29	6.11
X Variable 1	4.82	4.02	1.20

Selling Price/ sq m f.a. vs Distance from Traffic (m)
Reduced Data

Regression Statistics	
Multiple R	0.177
R Square	0.031
Adjusted R Square	0.005
Standard Error	284.14
Observations	39.00

	Coefficients	*Std Error*	*t Stat*
Intercept	826.97	189.65	4.36
Distance from road	10.96	10.04	1.09

Selling Price/ sq m f.a. vs Noise Level
Reduced Data

Regression Statistics	
Multiple R	0.163
R Square	0.026
Adjusted R Square	0.000
Standard Error	284.85
Observations	39.00

	Coefficients	*Std Error*	*t Stat*
Intercept	950.48	89.84	10.58
Noise Level	8.61	8.59	1.00

Selling Price/ sq m f.a. vs Noise Level
Reduced Data, Selling Price Adjusted for Street Price

Regression Statistics	
Multiple R	0.055
R Square	0.003
Adjusted R Square	-0.024
Standard Error	258.10
Observations	39.00

	Coefficients	*Std Error*	*t Stat*
Intercept	1006.64	81.40	12.37
Noise Level	2.62	7.78	0.34

Similarly, other variables such as visual screening index or distance from the traffic stream do not appear to offer any better prospects.

These findings are qualified by:

1. Traffic volumes need to be more accurately measured or estimated than was possible in the trial.

2. The house price index is based upon market changes over all of Auckland and could be modified to more closely reflect changes in the locality.

3. A composite measure of house "quality" could be developed and introduced to the model.

4. "Street value" will probably include some of the above quality attributes on an averaged basis so should not be included as the same time as (3).

5. Alternative functional forms of the model could be tried.

It could be that this particular residential suburb is atypical; however there are no grounds to suspect this to be the case. It might assist if a local real estate agent were to be approached to obtain information on property sales including detailed property descriptions (including internal features of the property) and the state of the market at the time of the sale.

Whether or not the hedonic pricing method is extended to a wider sample, it would first seem advisable to refine the analysis of this pilot group of properties which is comparable in size to the full samples in some of the overseas studies. If further analysis fails to reveal any correlation between traffic proximity and house price, then it is doubtful whether the hedonic pricing method should be taken any further, at least until the CVM alternative is thoroughly explored.

3.7 Contingent Valuation Pilot Survey

3.7.1 Choice Context for the Survey

It is important that survey respondents be faced with a hypothetical trading situation which they can visualise and relate to. Of critical importance is the means used to convey the monetary payment to interviewees. Two trade-off situations which could form the basis for a survey are:

- WTP to avoid additional traffic/encroachment/noise on their street (or WTP to have present noise levels reduced).

- WTP for noise screening or visual screening in the event of additional traffic.

Both these options have the difficulty that the context may be unrealistic (in the case of minor roads well away from existing or possible future roads) or, if it is a realistic possibility, then there will be respondent bias in the expectation that the results could be used as the basis for offers of purchase of the property.

In any case it may be difficult for individuals to visualise the effect on their particular property of a major change in the traffic flow. A further problem will occur in comparing properties on a main road for which the willingness-to-pay for environmental gain is at issue, with those on local roads where the WTP is to avoid an environmental loss. For these various reasons both the above approaches have been rejected.

What was hoped to be a more promising approach was to focus the interview on the choice of a new house given that a decision has been made (for unspecified reasons) to move house; and the choice is between properties which are equal in all other respects except for:

- price
- the volume of road traffic
- the proximity to, and the screening of, the dwelling from the road

This context has the advantage of being more realistic to people who have purchased a house in the past and may do so in the future, and in being conveyed as an unforced choice rather than an imposed situation in which respondents might object to paying for mitigating measures.

If the sample were drawn from the hedonic pricing survey sample, this would have the advantages that all respondents would have had recent experience of house purchase, and the current value of their property would be known to them and to the researcher.

However, for practical reasons the pilot survey for this study was carried out in Wellington by Malcolm Hunt Associates, and so the opportunity to use the Auckland hedonic pricing survey sample was not available.

3.7.2 Traffic Disturbance Attribute

For a contingent valuation survey, the traffic disturbance must be conveyed to the interviewees in a readily understandable form. It would be of no use to present dBA noise levels or traffic volumes to respondents and expect them to associate these with noise disturbance. Traffic volumes in vehicles/day or even vehicles/hour have little meaning to most people. Also, apart from traffic volume, other noise determinants such as the width of the carriageway, the number of heavy vehicles, set back of the property from the road and acoustic screening are all important exposure characteristics which can be more easily described to the interviewee.

As the choice context being suggested is moving to a new house, it is necessary to convey a realistic image of the physical layout and traffic conditions being offered. At the same time, this image will need to be closely relatable to actual traffic volume and composition, and physical measure of the environmental effect, such as 18h L_{10} dBA or an index of disturbance.

It was initially considered that either three or five levels of traffic volume, each matched to a road layout typical of the traffic volume level, be offered in the survey supported with photographs or sketch illustrations to help convey the nature of the conditions being described. In each case, the houses in the street would be owner-occupied properties of similar standard. The five levels are described below:

<u>Level</u>

1. No-exit street (about 7.5 metres wide); traffic levels low, speed low, individual vehicles can be heard coming; mainly residents cars with the occasional delivery or service vehicles; (100 - 250 veh/day).

2. Typical local residential street (about 7.5 metres wide); leading to three or four other residential streets but little or no through traffic; occasional delivery and service vehicles; about one vehicle each minute leaving in the morning and returning at night and a third of this during the day; traffic speed about 40 to 50 km/h; walking along the footpath is generally unaffected by traffic and crossing the road is easy (500 - 1,500 veh/day).

3. Busier and wider street (about 10 metres wide) forming a well-used route through the residential area, with some through traffic including some commercial delivery vehicles but very heavy vehicles only rarely. Walking along the footpath is not unpleasant but care is needed in crossing the road (2,500 - 7,500 veh/day).

4. Main commuter route for the residential area and other neighbouring suburbs; about 12.5 metres wide, two marked traffic lanes with a central painted median, and turning bays. Kerbside parking limited in places during peak periods. Traffic lights or roundabouts at main intersections and crossing the road in busy periods means walking to a pedestrian crossing or taking a lot of care. Used by buses and about 5% of the traffic is heavy vehicles. When walking along the footpath, traffic noise intrudes on conversation and there is some smell from vehicle exhausts (7,500 to 15,000 veh/day).

5. Main regional road, although still residential development through this area; about 17.5 metres or 60 foot wide, four lanes with no kerbside parking except where bays provided; crossing the road difficult except at traffic lights and pedestrian crossings which have central island refuges; speed limit is 50 km/h but the traffic stream is normally moving at 60 to 65 km/h and higher speeds at less busy times of day and at weekends; traffic is heavy during the morning and evening peak but is only a little less heavy during the day. About 7.5% of the traffic is heavy vehicles and walking along the footpath is unpleasant because of fumes and traffic noise (20,000 - 30,000 veh/day).

Three levels of traffic volumes, corresponding to 1,3 and 5 above were eventually decided upon as there was felt to be insufficient contrast between each traffic level if five were used and a lesser number would be easier both for survey application and analysis. However, it was recognised that the highest level could be rejected as an unacceptable choice option by some respondents and, if so, some modification to the description of the highest traffic volume level in the survey could be required.

3.7.3 Property Set Back Attribute

This refers to the distance of the building facade from the edge of the carriageway. It was anticipated that the base option for set back might have to be related to the experience of the respondent, that is to base the interview on the category that applies to their existing property. Three levels of this attribute were proposed as below:

Level

1. Narrow front yard - the front yard is 5 metres (16 feet) depth (boundary to the building facade) and the footpath width is 3 metres (10 feet) wide.

2. Average set-back - the front yard is 10 metres (33 feet) from the front boundary to the building facade and the footpath is 3 metres (10 feet) wide.

3. Deep set-back - the front yard is 15 metres (50 feet) from the front boundary to the building facade and the footpath is 3 metres (10 feet) wide.

At this stage of development of the survey it was decided not to include more extreme cases of property exposure to the road such as corner properties or right-of-way sections.

3.7.4 Property Screening Attribute

This attribute refers to the visual and acoustic screening of the property from the road. As a good acoustic screen implies a solid visual screen, the two attributes can be rolled into one, and the following three levels describing the screening effect were proposed:

Level

1. Open to the road - an open front yard, with a low fence or low bushes only along the boundary, and a few smallish trees; partial visual screening and no screening from traffic noise.

2. Visual screening only - trees and bushes along the front boundary and a wooden fence provides privacy from view from the road, but has little effect on shielding the front yard from traffic noise.

3. Fully screened - a solid wall, such as brick or stone, 2.0 metres high providing effective acoustic screening against traffic noise and privacy to the front yard.

3.7.5 Security Attribute

As mentioned above, a dummy variable could be used to represent a closed or open property boundary, to capture preferences associated with security of small children and animals, and of unwanted intrusion onto the property. However, it was judged that this would add a complication which would strain both the survey respondents and the analysis. Instead it is suggested that all properties be described as secure, even if in the unscreened case, the boundary is only a low fence and gate.

3.7.6 Money Attribute

The money variable, for which house price was the chosen quantity, could be dealt with in various ways:

- Suggest or elicit the general magnitude of house price that the house owner would expect to pay if they were to move, and then offset the price difference for environmental quality from that expected purchase price.
- Suggest only a dollar difference in price for the different choices without reference to an expected purchase price.
- Suggest a percentage difference in house price for the different choices, ignoring the actual purchase price.

The percentage difference is attractive for analytical reasons but does make the tacit assumption that the disutility of passing traffic is geared to the house value. Also a percentage of the house price may be less readily understood by some respondents. Provided the base value of the house is established in the mind of the respondent, then a dollar quantity difference is probably preferred.

The hedonic pricing study would have established an average property value for the area. This could then be used as the base value for an average property on a typical residential street, average set-back and partially screened from the road. For the following discussion the value is assume to be $200,000 (about the average single dwelling value in Auckland and Wellington at the time of the survey).

Hedonic pricing studies have indicated that traffic noise exposure can be related to property value at the rate of 1 dBA equivalent to 0.5% of the property value, that is $1,000. The above traffic characteristics, set back and degree of acoustic shielding can be translated into predicted L_{10} dBA levels using the CRTN method which has been verified as applicable for use in New Zealand, as shown in Table 7.

The range of noise exposure at the facade over the 5 different traffic scenarios varies from the background level, assumed to be about 50 dBA 18h L_{10}, to 68 dBA assuming an average set-back without acoustic screening in each case. This implies a range in value of $13,000 or 6.5% of the mean property value if noise exposure is taken as the main indicator of disutility. The difference between each traffic level is about 6 dBA for traffic above 2,000 veh/day. For the two lowest traffic levels, the L_{10} traffic noise level at the facade will be indistinguishable from the background. An equivalent trade-off for property value against noise would be about $5,000 per change in traffic category if the 0.5% of value per dBA is borne out.

The acoustic screening attribute has an attenuation effect of about 19 dBA, effectively reducing the traffic noise component below the background level. The choices for the three levels are therefore very stark - no visual/no acoustic screen; visual screen/no acoustic screen; visual screen and acoustic screen. Although this may exaggerate what can normally be achieved in practice, it does allow visual and acoustic effects to be separated in the survey. The difference between no acoustic screen and fully screened will vary according to the traffic level and set-back.

The set-back attribute gives a range of noise exposure of about 7 dBA. The difference between options is therefore just above the threshold of perceptible change in noise level, and this perhaps would need to be brought out in the interview survey. The set-back affects the usability of the front yard, and the interview technique should make clear whether a narrow front yard means more space at the back so that the section size is maintained, or a smaller section with a similar size backyard in each case. Using noise exposure difference and 0.5% NDI against property value, each step in property set-back should equate to $3,000 in house price, but a larger unit should probably be used as the visual amenity will improve as the front yard is widened. It is suggested that $5,000 again be the unit difference presented in the survey choices.

Table 7 Predicted Traffic Noise Levels, for various traffic, set-back and screening attributes

Traffic Volume veh/day	Speed km/h	Heavy %	Medium Large ratio	Road Surface	Set-Back	Screen	L10 dBA (18 h)				
							Front Yard	1m from Facade	Internal		
									Closed Windows 10%	Closed Windows 75%	Open Windows
250	55	1	8	Chip	Close	None	51.2	BNL	BNL	BNL	BNL
						Visual	51.2	BNL	BNL	BNL	BNL
						Acoustic	BNL	BNL	BNL	BNL	BNL
					Average	None	BNL	BNL	BNL	BNL	BNL
						Visual	BNL	BNL	BNL	BNL	BNL
						Acoustic	BNL	BNL	BNL	BNL	BNL
					Far	None	BNL	BNL	BNL	BNL	BNL
						Visual	BNL	BNL	BNL	BNL	BNL
						Acoustic	BNL	BNL	BNL	BNL	BNL
5000	60	5	5	Chip	Close	None	66.3	64.4	BNL	BNL	54.4
						Visual	66.3	64.4	BNL	BNL	54.4
						Acoustic	BNL	BNL	BNL	BNL	BNL
					Average	None	63.9	60.5	BNL	BNL	50.5
						Visual	63.9	60.5	BNL	BNL	50.5
						Acoustic	BNL	BNL	BNL	BNL	BNL
					Far	None	61.9	57.7	BNL	BNL	47.7
						Visual	61.9	57.7	BNL	BNL	47.7
						Acoustic	BNL	BNL	BNL	BNL	BNL
25,000	65	7.5	3	A/C	Close	None	73.1	71.0	BNL	43.0	61.0
						Visual	73.1	71.0	BNL	43.0	61.0
						Acoustic	53.9	51.9	BNL	BNL	41.9
					Average	None	70.5	66.9	BNL	BNL	56.9
						Visual	70.5	66.9	BNL	BNL	56.9
						Acoustic	51.5	BNL	BNL	BNL	BNL
					Far	None	68.3	63.9	BNL	BNL	53.9
						Visual	68.3	63.9	BNL	BNL	53.9
						Acoustic	BNL	BNL	BNL	BNL	BNL

Notes: background noise level (BNL) assumed: 50 dBA external, 40 dBA internal

3.7.7 Design for a Preference Ranking Survey

3.7.7.1 Form of Survey

The aim of a preference ranking survey is, for each respondent, to obtain a preference ordering for combinations of each attribute at each level. In its most extended form this would involve asking each respondent to indicate his or her preference for one or other of a set of attributes, and repeating this process over all possible combinations of attribute levels. The process can be compressed by asking the respondent to put sets of attribute choices into a rank order of preference.

3.7.7.2 Four Attribute Ranking Survey

If the survey is to cover attributes of (a) traffic/road layout (3 or 5 levels), (b) set-back (3 levels), (c) screening (3 levels) and (d) house purchase price (say 3 or 5 levels), this produces between 81 and 225 combinations, which is certainly too great a number for a survey respondent to rank. The number can be reduced by reducing the number of levels of attributes, by eliminating attributes altogether and by adopting a fractional factorial survey design (in which it is assumed that each variable is independent of the other and that interactions between variables are negligible). Further reduction can be achieved by not including choices between extreme combinations of attributes for which the preference is obvious (such as high traffic/close set-back/no screening/high price with low traffic/far set-back/acoustic screening/ low price).

To reduce the survey choices to a manageable level for 4 attributes would require the attribute levels to be reduced to 2 wherever possible and 3 at the most. The minimum for the screening attribute is 3 to combine acoustic and/or visual screening options. For the traffic attribute, again a minimum of 3 levels is needed to obtain the requisite degree of definition, bearing in mind that annoyance may not be linearly correlated with the suggested traffic levels. Set-back could be reduced from 3 to 2 levels (close or far) but this makes both choices atypical which may not be desirable. The money variable could be reduced to high or low cost, but as possible boundary values can only be anticipated for traffic noise at this stage, as many levels of the money attribute as possible would be preferred and certainly not less than 3.

The choice of attributes is clearly defined and by their nature the attributes are independent, but the assumption that interactions are negligible cannot be readily tested. The choice options for a 3 x 2 x 3 x 3 matrix could be offered as a ranking of choices as indicated in Table 8, with the rows rearranged into a random order. However, there is the distinct prospect that this ranking exercise even in its reduced form could be too demanding for the survey respondents.

3.7.7.3 Two Attribute Ranking Surveys

An alternative approach would be to decompose the survey into a number of sub-surveys covering price plus one other attribute at a time, with other attributes set at an average level or possibly explored at high and low levels. This would allow more flexibility in the number of levels of attributes included.

A possible survey plan would be as follows:

(i) Traffic level versus price (assuming a partially-screened frontage and average set-back) 3 traffic levels and 3 or 5 price levels could be ranked.

(ii) Screening vs price (assuming an average set-back of the house from the property boundary and explored at low and high traffic levels) 3 screening options and 3 or 5 price levels.

(iii) Set-back vs price (assuming a partially-screened frontage and applied at low and high traffic levels) 3 setback options and 3 to 5 price levels.

3.7.7.4 Merits of Each Approach

For a first-time study, we suggest that a two attribute approach is preferred. It should be more straightforward to apply, as respondents will not be required to weigh up several attributes at one time, and will allow "boundary" values between the attribute levels to be determined before progressing to a more complex survey design. The surveys could be applied as a rank ordering, or transfer-pricing could be explored in the initial stages to gain some insight into the range of monetary trade-offs.

A disadvantage of the two attribute approach, if it is applied for more than one pair of attributes to the same group of respondents, is that the time required for the survey and the number of questions involved may become too onerous on both the questioner and the subject. In this case separate surveys would have to be applied to different respondent groups - which then has the disadvantage that there is no guarantee if commonality in the preferences of each sample, or return calls could be made to carry out each of the two attribute surveys.

3.7.7.5 Analysis Method

A preference ranking survey of the type proposed is amenable to a logit modelling form for which various standard statistical analysis packages are available, such as the Australian Road Research Board B-logit software, and it is anticipated that such a package would be used for the CV survey analysis. However this aspect still requires further definition.

Table 8 Possible Fractional Factorial Preference Ranking Survey Design with Four Attributes.

Option	Traffic Level	Set-back	Screening	House Price
1	low	near	none	low
2	low	near	visual	medium
3	low	far	acoustic	high
4	medium	far	none	medium
5	medium	near	visual	high
6	medium	near	acoustic	low
7	high	near	none	high
8	high	far	visual	low
9	high	near	acoustic	medium

3.7.8 Application of the Pilot Survey

3.7.8.1 Further Development of the Questionnaire

The pilot survey questionnaire was designed in five sections:

1. Preference questions for traffic volume/street layout versus house price,
2. Preference questions for traffic volume/street layout versus screening,
3. Preference questions for traffic volume/street layout versus set back,
4. Household and personal data, and
5. Likes and dislikes about traffic and layout of the street.

The personal and household data will allow the frequencies of the household types and incomes in the survey to be compared against population totals when the survey is taken beyond a pilot stage. The general questions about preferences at the end of the survey were designed to elicit information which could be useful in improving the comprehension of the survey, deciding on likely boundary levels for attributes, and which attributes should be considered for inclusion in an improved survey design. One of these final questions directly asked whether traffic played a part in the decision on house purchase.

A question was also included which asked whether the respondent had discovered "anything about the house, its situation, or the road traffic since you moved in here?". This was intended to probe for any aspect of the property which was not perceived at the time of purchase and could affect an hedonic pricing valuation.

3.7.8.2 In-House Trials

The early drafts of the survey questionnaire were trialled in-house by Malcolm Hunt Associates for fluency and comprehension. Following this, the survey was handed to a market survey specialist who suggested amendments aimed at making it easier to administer.

At this stage it was decided that photographs of typical road layouts and traffic would not be a suitable way for conveying an impression of the road to respondents. The photographs inevitably identified a location which could be recognisable and carried in their detail extraneous information on the street that could lead the respondents to react to attributes which the survey design was not intended to convey. In other words, photographs would not be neutral in the information conveyed.

To address this problem a graphic artist was employed to produce drawings of the three road layouts and traffic densities (Figures 1 to 3).

At the suggestion of the market survey specialist, the form of the questionnaire was changed from a ranking preference survey to a direct "bidding game" approach, with the money attribute expressed as a scale of "extra you would be willing to pay for a house on the (quieter) street". This made the survey easier to administer but also introduced the possibility of biases inherent in this type of approach. The bidding scale varied from zero to $50,000 which was expected to bracket the range of likely values. (The survey questionnaire and prompts are shown in the Appendix.)

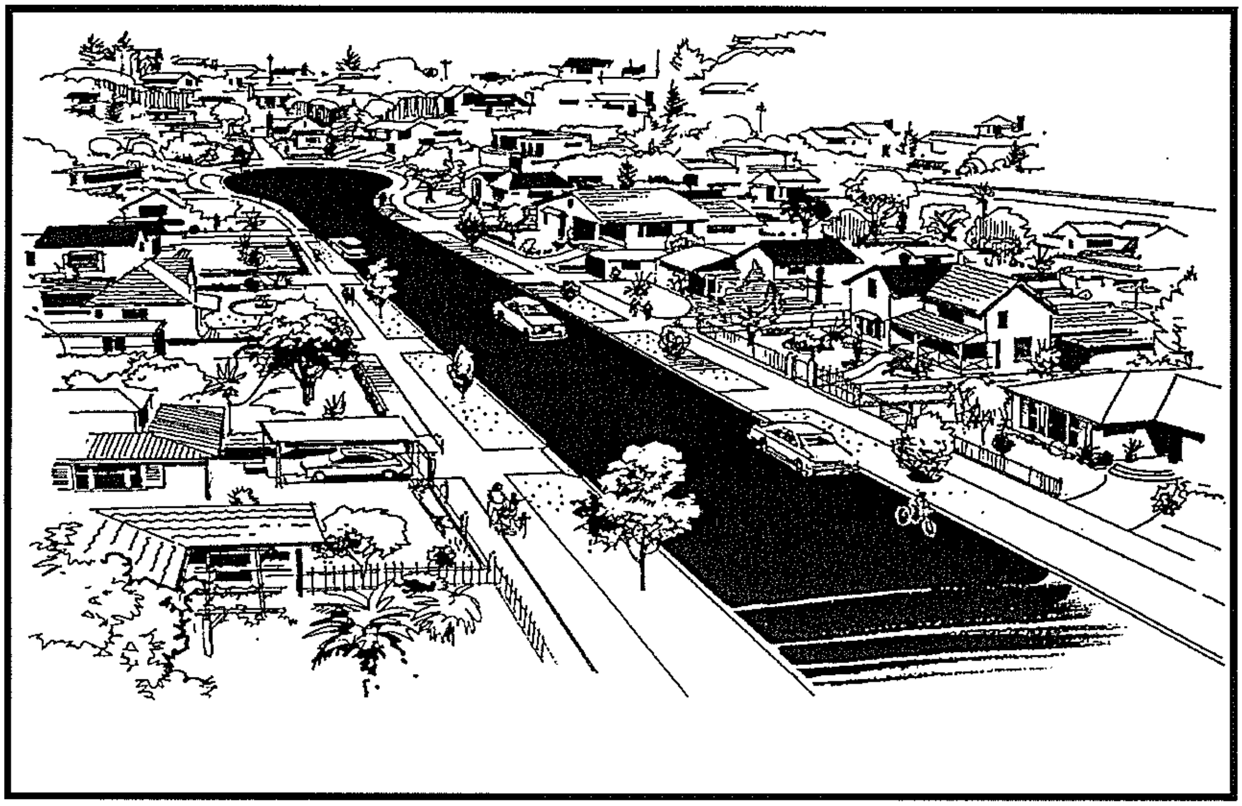


Figure 1 Artist's sketch of a "Quiet" residential street

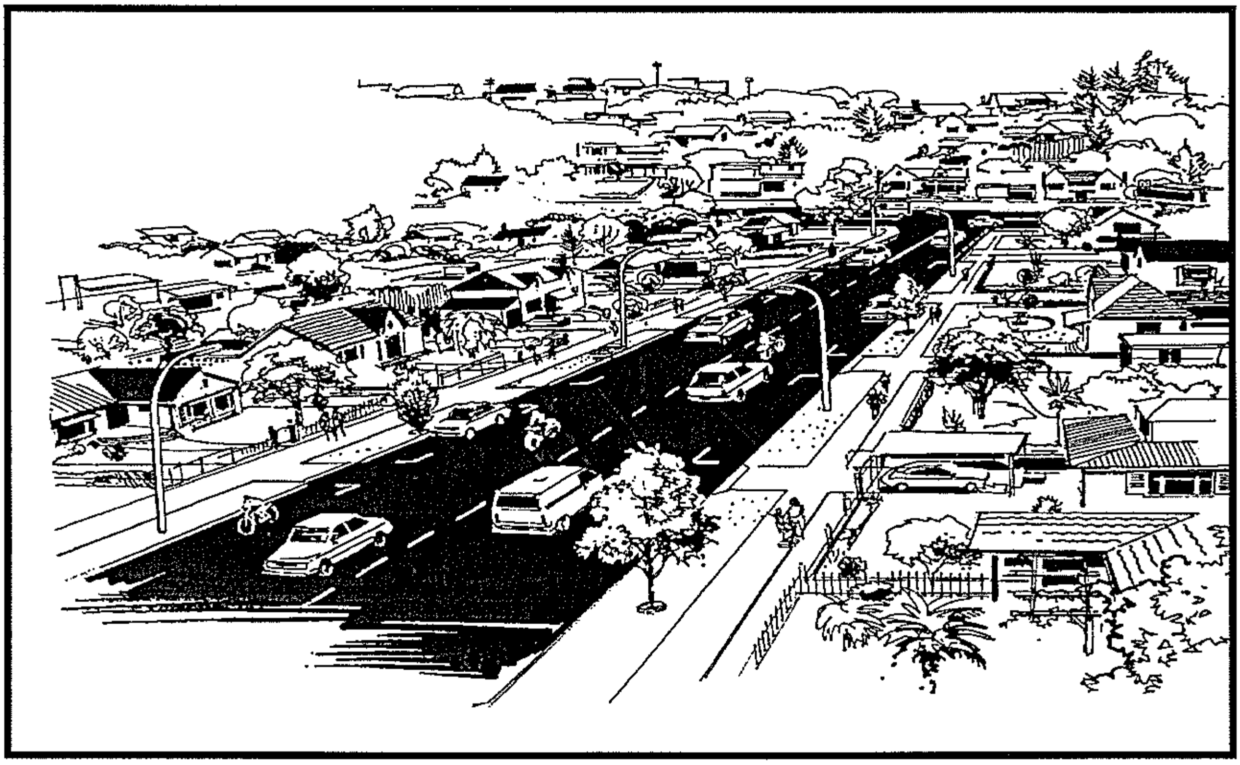


Figure 2 Artist's sketch of a "Less Busy" residential street

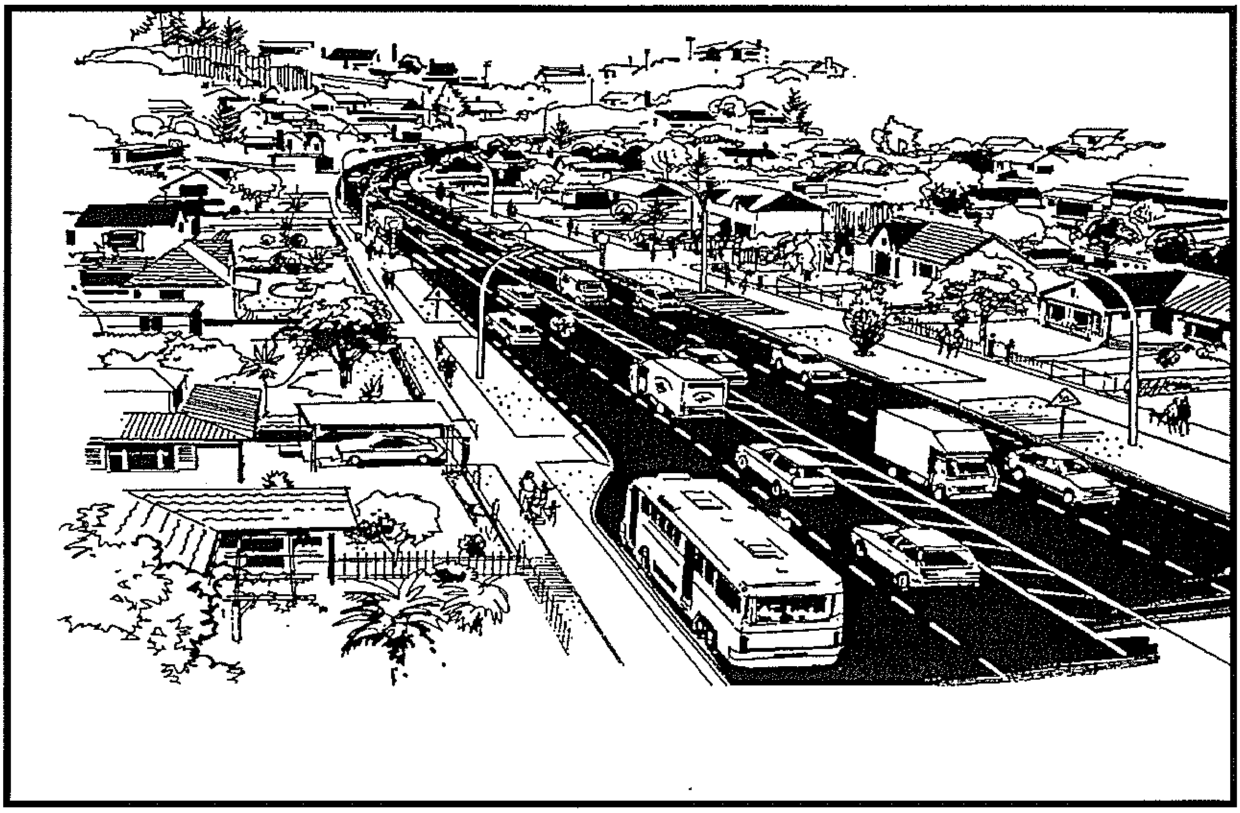


Figure 3 Artist's sketch of a "Busy" residential street

3.7.8.3 Pilot on 15 Respondents

The survey was then piloted on 15 individuals by the market researcher. The survey was generally well received, in that respondents understood the questions being asked and felt capable of making a decision on the choices being presented. The pilot revealed a problem that the survey questionnaire was not sufficiently specific in identifying whose house was being valued or in establishing the base value of the property. These deficiencies can be easily remedied should the survey be taken further.

The survey responses are shown in Table 9 and 10, and summary statistics for the sample in Figures 4 to 7.

Only one out of 15 respondents was unable to offer any answers to the questions asked and four out of 15 gave a non-zero answer to all questions. The questions relating to traffic conditions in the street appear to have been the easiest to comprehend. The highest response rate was to the question on willingness to pay for a less busy versus a very busy road (14 out of 15). The questions regarding type of section (corner, frontage or rear) were least fully answered.

Table 9. Responses to Pilot Contingent Valuation Survey

Record	Q1A $ WTP extra for less busy than very busy street	Q1B $ WTP extra for quiet than less busy street	Q2 $ WTP for visual /noise screen	Q3A $ WTP for frontage versus corner section	Q3B $ WTP for rear versus frontage section	Age	Income
1	10,000	0	0	10,000	0	o	m2
2	0	0	0	0	0	y	m1
3	30,000	10,000	7,500	5,000	5,000	y	m1
4	10,000	0	0	0	0	m	l
5	5,000	0	7,500	0	0	y	m2
6	15,000	5,000	7,500	0	10,000	m	h
7	10,000	0	10,000	0	0	m	m2
8	7,500	10,000	5,000	5,000	0	m	m1
9	7,500	10,000	5,000	5,000	2,000	y	l
10	20,000	0	10,000	0	5,000	m	h
11	10,000	5,000	5,000	2,000	0	o	h
12	25,000	15,000	5,000	10,000	0	y	m1
13	15,000	2,500	0	0	0	o	h
14	20,000	15,000	2,500	10,000	7,500	m	h
15	5,000	20,000	15,000	5,000	15,000	m	h
16	15,000	7,500	0	0	10,000	o	h

Notes: y = young age group, m = middle age group, o = older age group
l = lower income group m= middle income group, h =high income group

Where WTP answers were given, the highest value was $30,000 by one subject for a house on a less busy rather than a very busy road. There was some difference in the results depending on the interpretation of zero bids. The fact that there are zero bids also implies that the opportunity for negative bids should be provided in any further surveys.

For example the question concerning a corner section could easily bring in non-road attributes which attract people to such a property. In the pilot there was no probing of the zero responses.

Table 10 Summary of Willingness to Pay Responses ($ 1993 values)

Question	Include/Exclude Zero Bids (no.)	Mean of Response	Maximum Response	Minimum Response
Less Busy Street over Very Busy Street	Include	12,813	30,000	0
	Exclude (1)	13,667	30,000	5,000
Quiet Street over Less Busy Street	Include	6,250	20,000	0
	Exclude (6)	10,000	20,000	5,000
Screened over Unscreened	Include	5,000	15,000	0
	Exclude (5)	7,273	15,000	2,500
Frontage over Corner Section	Include	4,500	20,000	0
	Exclude (8)	9,000	20,000	2,000
Rear over Frontage Section	Include	3,406	15,000	0
	Exclude (9)	7,786	15,000	2,000

However, for the main question on traffic, the mean bid for a less busy compared with a very busy street was around $13,000 which corresponds to 6.5% of a typical $200,000 property price. This bought approximately 6.4 dBA of reduction in facade noise level, equivalent to 1% of property price per dBA.

For the quiet street versus the less busy street the mean WTP was between $6,250 and $10,000 depending on the treatment of zero bids. This bought 10.5 dBA reduction in facade noise level (0.3% to 0.5% of property price per dBA). These results, while limited by the small sample and pilot nature of the survey were not inconsistent with hedonic pricing values. The implication that the relationship between WTP and property price might not be linear is not unreasonable considering the logarithmic scale of noise measurement and has been suggested in the literature.

If considered in relation to traffic volume, the WTP to reduce traffic from the very busy to the less busy street was $1.50 per unit of traffic volume in vehicles/day (or 0.3% of property price per 1,000 vehicles per day) and from a less busy to a quiet street $1.30 to $2.10 per vehicle/ day (or 0.6% to 1.0% of property price per 1,000 vehicles per day).

The value of a heavy visual and moderate acoustic screen to an open frontage averaged $5,000 to $7,273 or 2.5% to 3.6% of property value (depending on the inclusion of zero bids). The screening attribute was therefore found to be significant and of similar order of magnitude to noise attenuation.

Preferences for corner, frontage and rear sections will of course be correlated to noise exposure. While this question was less well answered, there did appear to be a difference in value between each of these types of frontage. The differences between each level of exposure appeared to be of similar order of magnitude to the screening effect.

The data was segmented by age and income as shown in Figures 4 to 7. No major income differences were apparent, although the data are very thin. Neither was there any marked difference with age of householder. However, very little should be read into the disaggregation by age and income at this pilot stage.

3.7.9. Conclusions from the Pilot CV Survey

The pilot survey gave promising results. The context of moving to a new house appears to be a sufficiently neutral method of conveying the willingness-to-pay. It implies voluntary choice and does not implicitly lead the respondent to give a strategic bias to the answer as there is no suggestion of a real payment or compensation. As with all CVM surveys, there is the possibility of hypothetical bias.

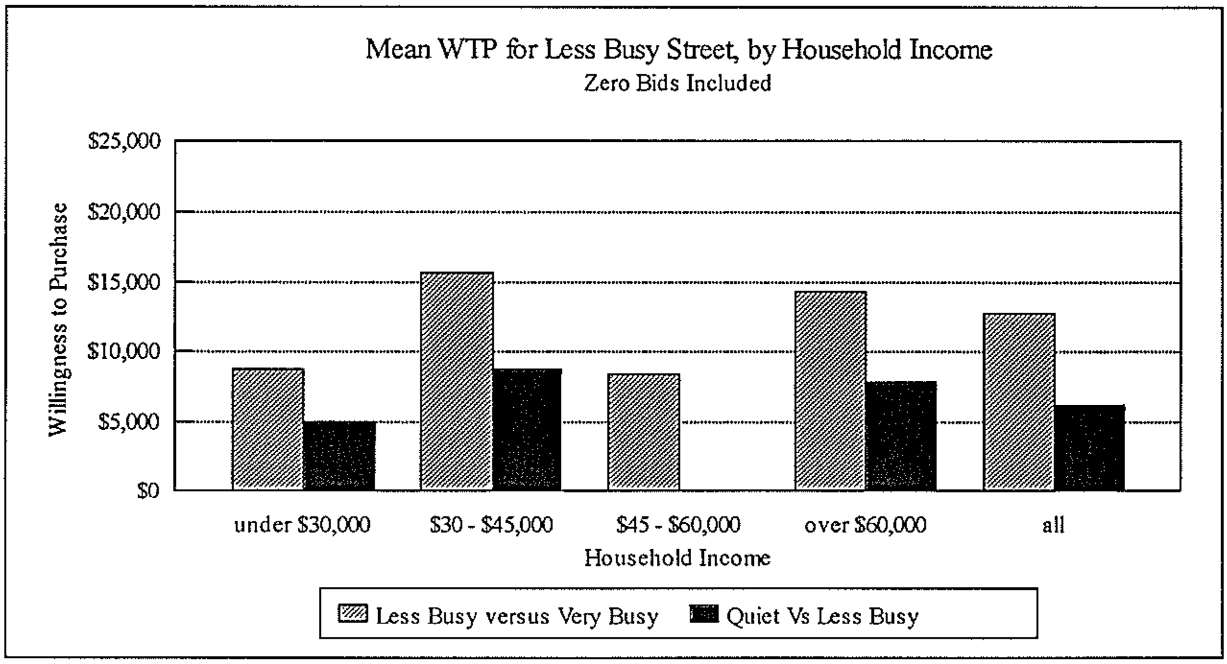
While very preliminary, the numerical results indicate a possible level of WTP for traffic disturbance in the region of 0.3% to 1.0% of property value per 18h L_{10} dBA of noise exposure, with the possibility of a non-linear relationship, the WTP being higher at higher levels of exposure. There does appear to be a need to include screening of the property from the road as another dimension of the WTP value.

The method of administering the survey needs more development, and a possible next step should be to trial the survey on a larger number of respondents (say 50) using two methods:

- Direct questioning of willingness-to-pay using a payment card, but allowing negative bids, and

- A preference ranking survey, combining the attributes of traffic level, visual and acoustic screening.

Following this further round of trials there would be a larger data set on which to test analysis techniques. When the techniques are developed, then a full scale survey should be considered.



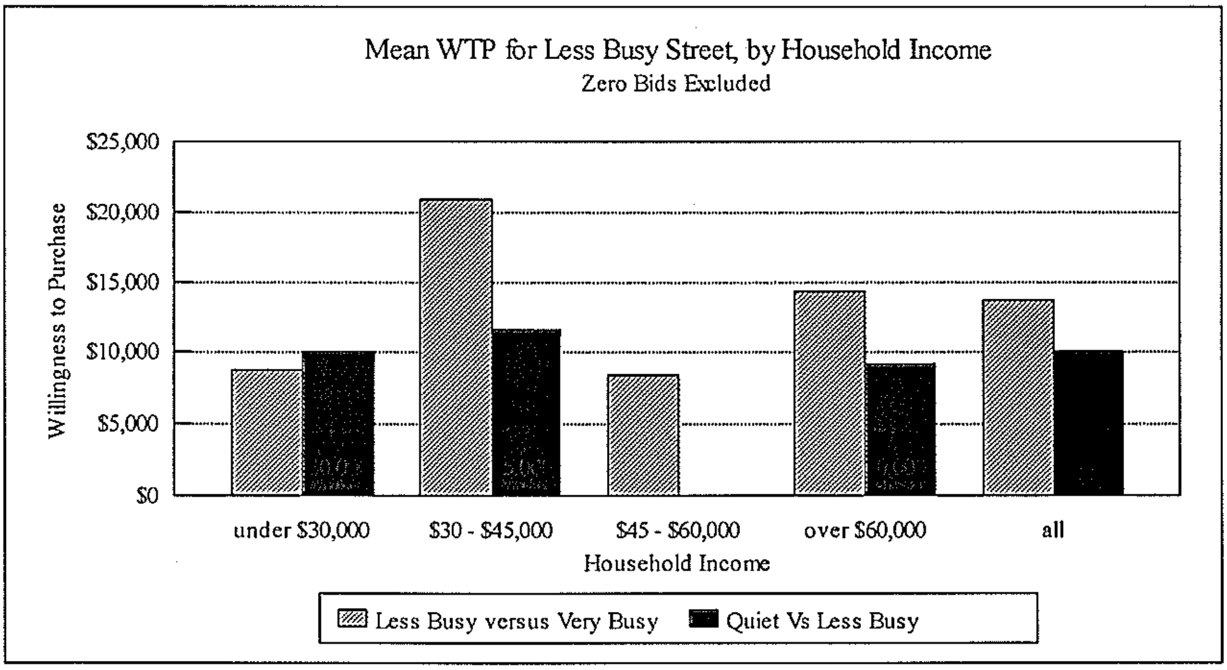
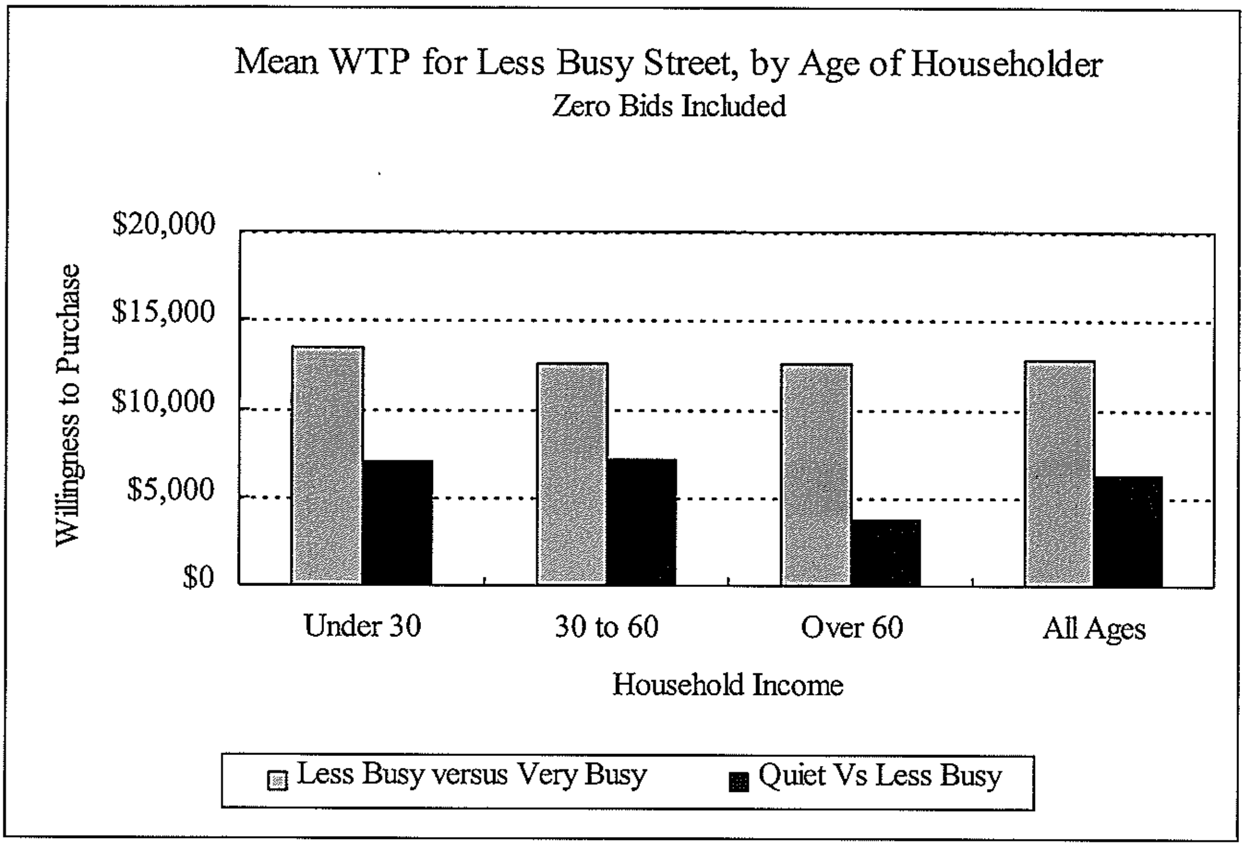


Figure 4 Pilot Sample - WTP for House on Quieter vs Busier Street, by Income



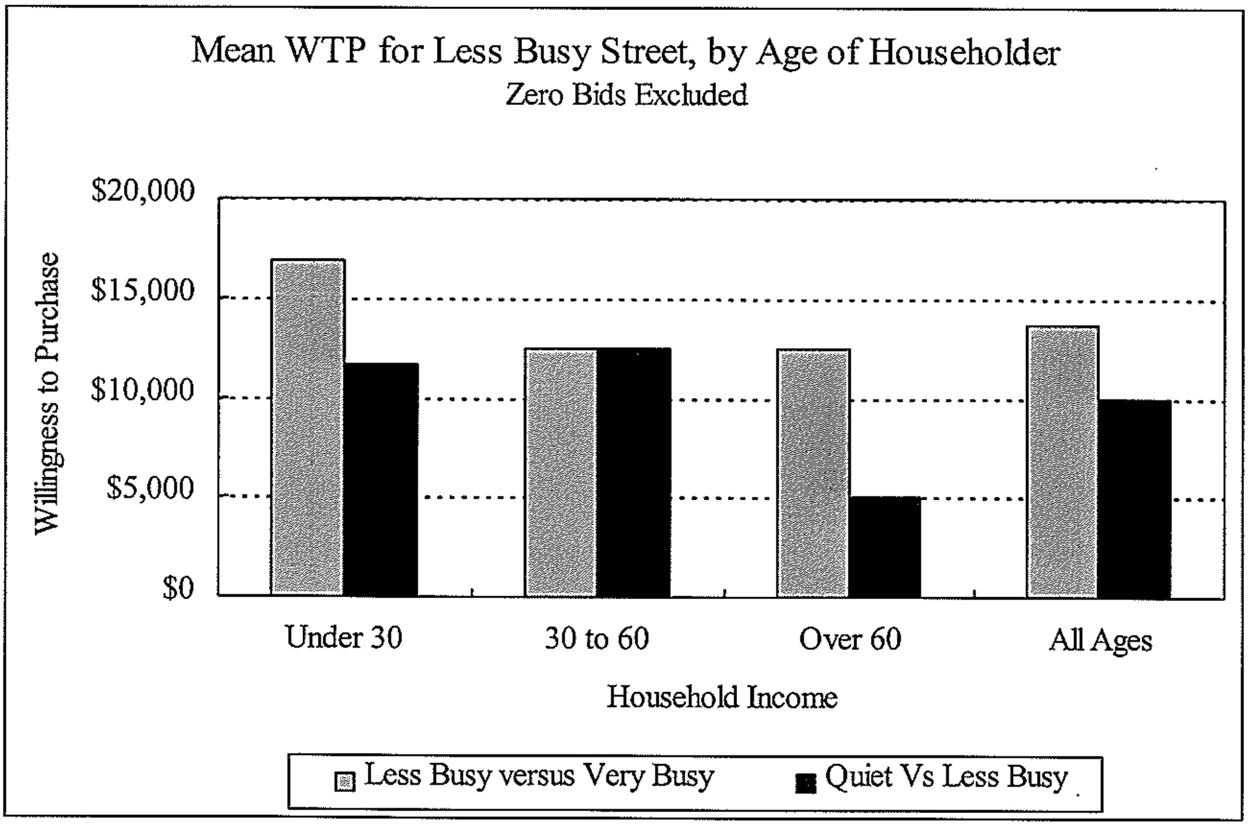
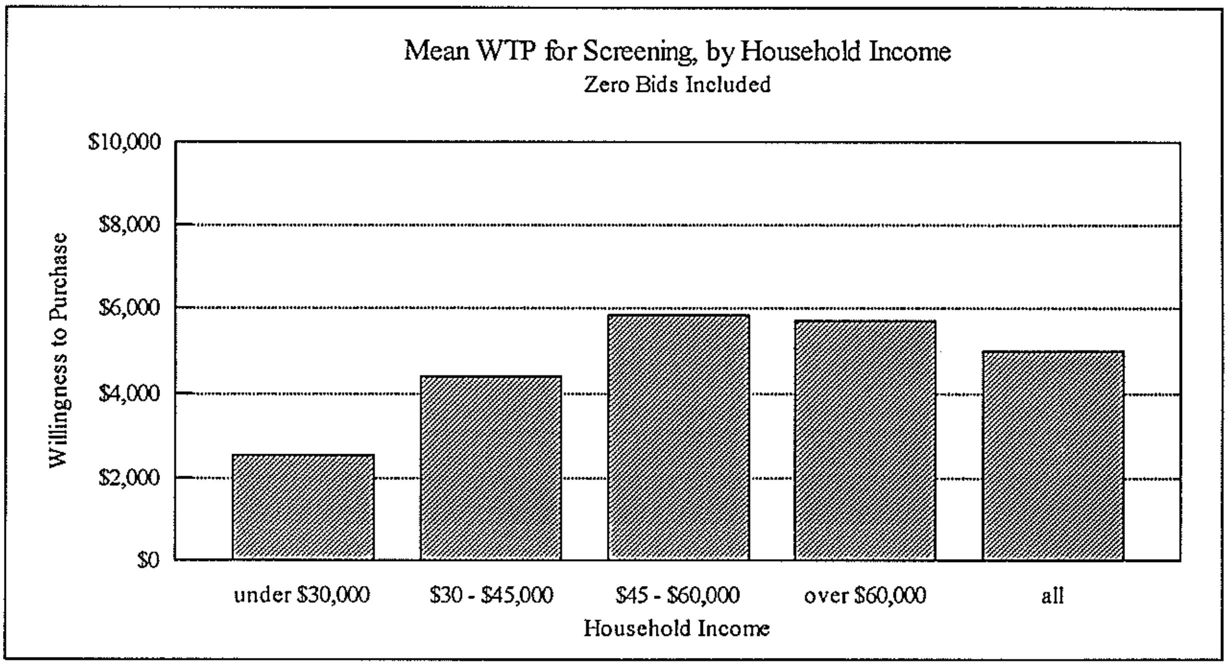


Figure 5 Pilot Sample - WTP for House on Quieter vs Busier Street, by Age



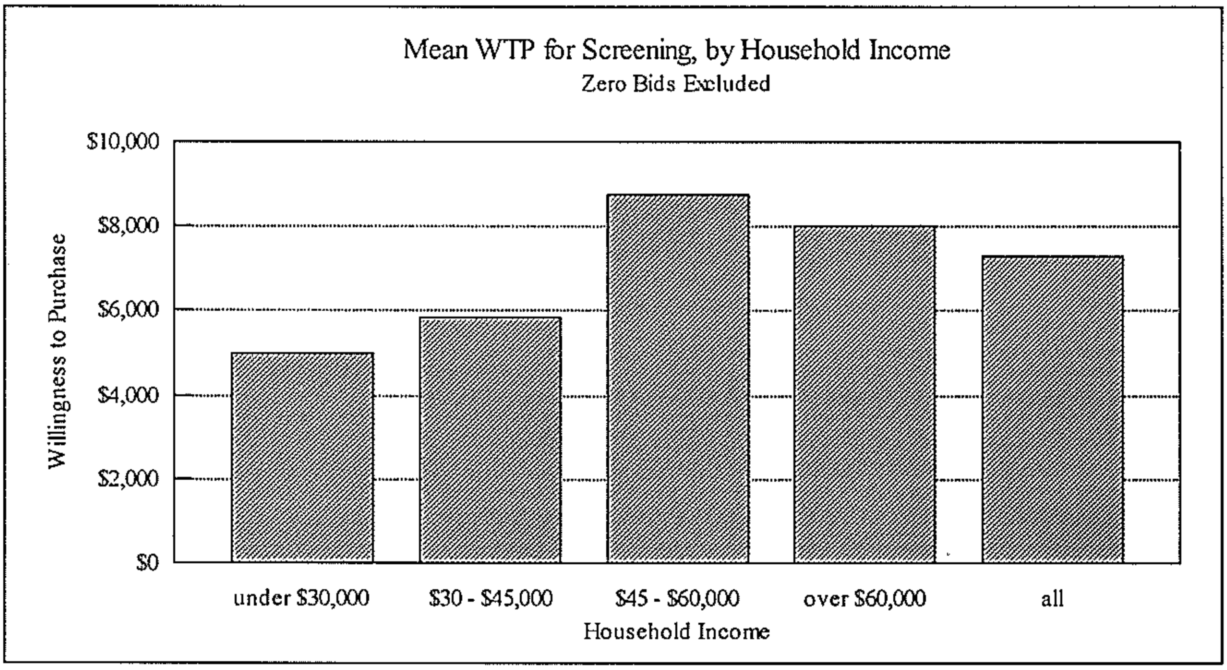
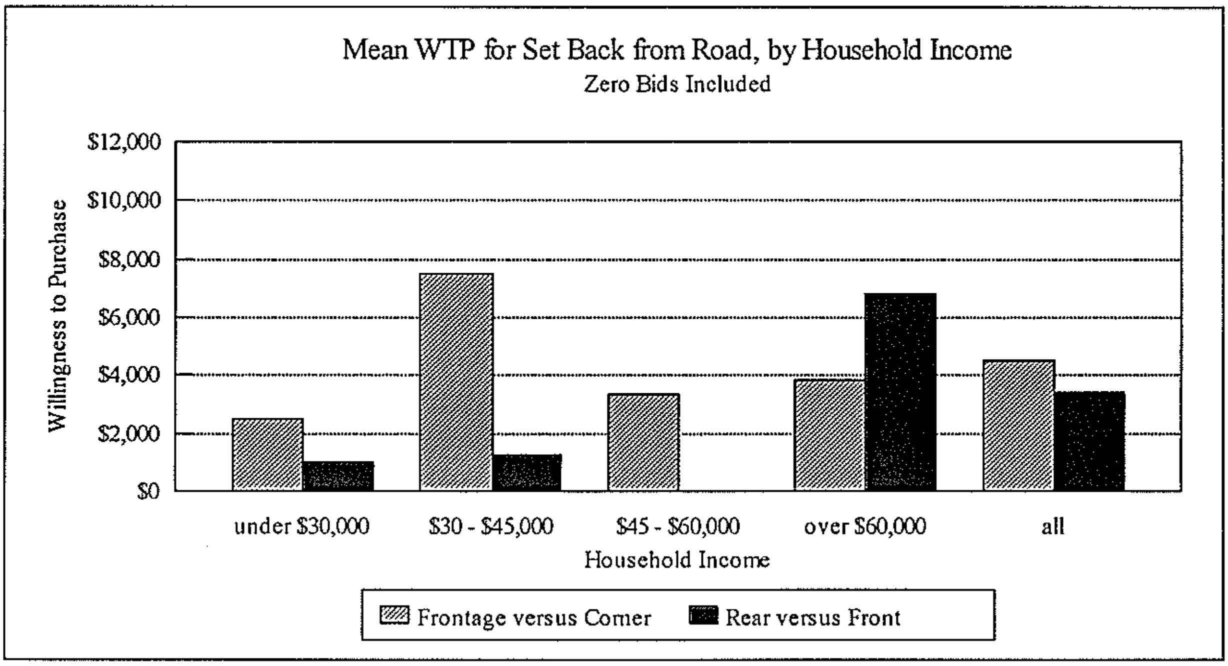


Figure 6 Willingness to Pay for Visual and Acoustic Screening



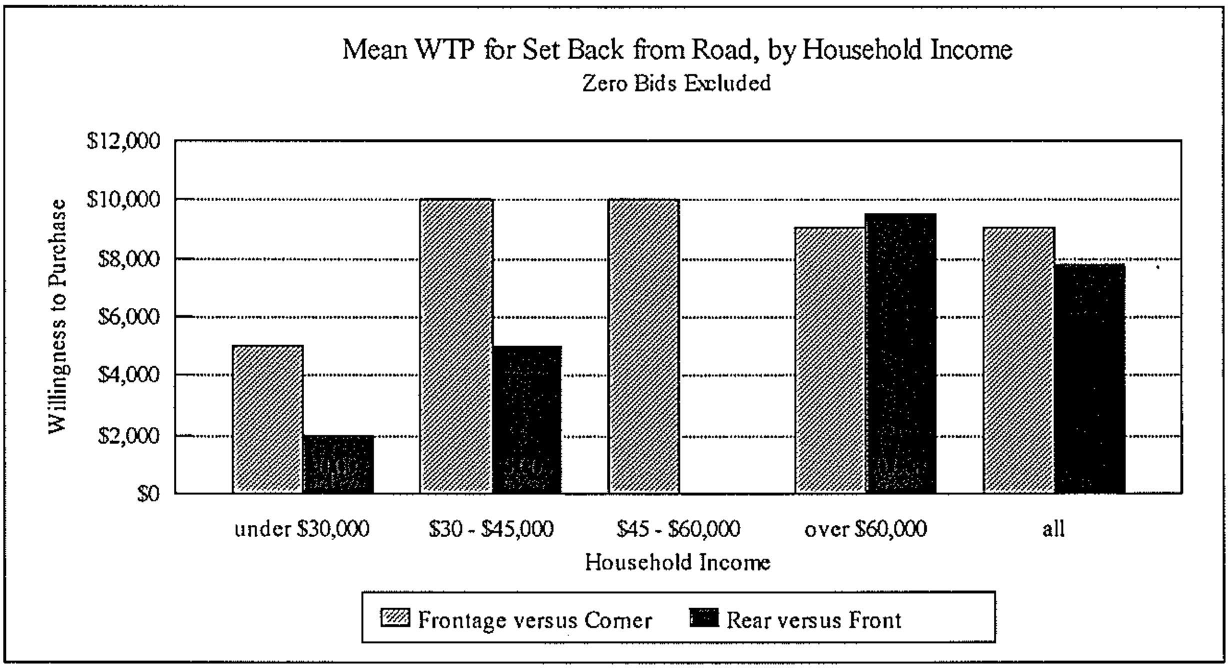


Figure 7: Willingness to Pay for Property Set-Back, by Income Group

4 COMMUNITY SEVERANCE

4.1 Introduction

One of the objectives of the research project was to review the methods employed for valuing the severance effects of road traffic. Severance, also known as "barrier effect", is not necessarily correlated with other common environmental effects of traffic such as noise, air pollution and visual impact. It therefore needs to be dealt with separately in the evaluation of projects.

4.2 Present Treatment

The TNZ draft Project Evaluation Manual (May 1995) takes as its definition of severance "the dislocation and alienation a community feels as a result of roads which sever communities or hinder access. It includes the effect of traffic on security and mobility of people, particularly pedestrians and cyclists and the consequential effects on their movement patterns and interaction."

The PEM provides general guidelines on quantifying severance by gathering information on prior movement patterns and then analysing how trips across the barrier will be lengthened, redirected or suppressed by the road facility. In evaluating severance, a distinction is made between the tangible effects, such as additional trip times for pedestrians and cyclists which can be quantified and valued, and intangible effects. What the intangible effects are precisely, and how double counting can be avoided, is not really addressed.

4.3 Practice in Other Countries

A small quantity of information was located on the treatment of severance in overseas countries.

4.3.1 United Kingdom

The U.K. Manual of Environmental Appraisal (Department of Transport 1983) used a slightly different definition for severance: "the separation of residents from facilities and services they use within the community, from friends and relations and, perhaps, from place of work as a result of changes in road patterns and traffic levels." This definition and the subsequent treatment emphasised the severing effect of a roadway, but did not deal with the consequential community impacts.

The advice given on quantification was generally directed towards mapping movement patterns, giving separate consideration to the young and old, quantifying the number of pedestrian and cycle trips likely to take longer or be curtailed (admitted to be a difficult process), and then classification of the severance effect into three general categories of "slight", "moderate" and "severe". From that point the severance was put into a summary table of effects, similar to that advocated by Transit New Zealand's current procedures.

4.3.2 Germany

Guidelines for investment in transport projects for federal projects in Germany reported by PLANCO 1985 included severance measurement. The example given was for reduction in severance by the construction of urban bypasses. The methodology was based on disruption to crossing movements and provided typical data for most situations.

The first step was to classify the road, from which a formula for average time loss per crossing of the road was provided according to traffic volume. A further table provided average crossings per person per day by type of road. A formula combining these factors totalled the time losses to which a value of time was applied.

4.3.3 Sweden

The Swedish National Roads Administration (1986) divided barrier effect into transverse and longitudinal barriers.

For transverse barriers, a series of charts and formulae were provided as in the German example to calculate the quantum of barrier effect. Three "environment types" were covered, similar in nature to the German classification of roads. The Swedish classes were: centres of urban areas with 50,000 inhabitants; suburban parts of urban areas with 50,000 inhabitants; and rural villages. Tables gave the typical number of road crossings cross-classified by age group, by foot or bicycle and by trip purpose. These trip rates were then applied using a map showing the distribution of residences and probable destinations, such as schools, bus stops and workplaces. The disturbance (extra time) to cross the road was calculated from traffic volume, percentage of trucks and traffic speed with the assistance of a graph of correction factors against speed. Finally, the costs were calculated using valuations which varied with age group; these were higher for young and old than for adults between 13 and 65. Various corrections were made for aids in crossing the road such as signal controlled pedestrian crossings and pedestrian subways.

For longitudinal barriers, the effect measured in the Swedish procedures was actually a measure of intimidation caused to cyclists by being overtaken by streams of motor traffic. Again, there was a differentiation by age group.

4.3.4 Denmark

The Danish Roading Directorate (1980, 1990) included barrier effects in its State Highway Priority Model. It defined barrier effect as "the restriction in the individual's freedom of movement caused by the traffic on the roads. It includes the possibility of moving freely near one's house enjoying services in the neighbourhood, schools and other amenities without the traffic being too great a hindrance."

The DRD recognised that some areas within cities acted as coherent units and had less requirement for crossing of main roads at their boundaries than in other areas where the road cut across linkages within a community.

The barrier effect was recognised to depend on: the need to cross the road; road layout; traffic density and speed; and number of controlled crossing points. The DRD acknowledged that it was not possible with the data normally available to calculate the suppressive effect of an existing barrier. Because of the absence of data they developed an estimation method based upon the building type and density alongside the road. The relative demand for crossing movement was calculated as the product of factor weights for development on each side of the road and the length of the road section. The barrier presented by the road was rated on a scale of 1 to 7 according to traffic speed and volume. The barrier effect was the product of the relative demand for crossing movements and the rating of the barrier. This was further factored by another index to allow for the perceived risk of walking or cycling alongside the road in the process of circumventing the barrier to give a rating number. This could be up to 50% above the basic unfactored rating.

To arrive at an equivalent cost of barrier effect the rating number was then multiplied by a cost per unit. The cost per unit did not derive from any formal non-market valuation, but was a product of the DRD's overall policy for allocating weights between quantifiable road user costs and intangibles. For example between 1981 and 1987, the DRD decided to give equal weight to total road user cost savings and total environmental improvements in its project selection. Having made this 50:50 weighting, it was then decided to weight priorities between noise, barrier effects and air pollution in the ratio 60:30:10. The actual cost per unit of barrier effect was then derived from the aggregate barrier effect ratings from all projects in the annual program and the total funding allocation towards barrier effect reduction. It may be noted that noise and air pollution costs were derived from WTP valuations, and only the barrier effect was valued in this nominal way. The unit values appear to have varied considerably from when the procedure was first set up, the unit cost of barrier effect having reduced significantly over the period.

4.4 Issues in the Valuation of Severance Effects

4.4.1 Severance Measured from Delay to Cross-Movements

Severance effects can be regarded narrowly as a valuation of the additional time to cross the road, as in the northern European examples above, or can be viewed in a broader way as the consequential effects of restrictions on linkages and communication in the community. An analogy can be drawn with the quantification of road user cost savings as the measure of road transport benefits which then flow through to accessibility and land value changes, additional disposable time and income. There is a probable element of double counting if severance costs are assessed from the costs imposed on pedestrians and other traffic affected by the road barrier and then a further assessment is made of the consequential impacts. As with road user savings, the diffuse effects of severance are difficult to quantify but the immediate effects are definable.

Consequently, an aggregate measure of severance costs will probably be largely obtained from an analysis of changes in total delay to persons crossing the road together with an appropriate treatment for redistribution and suppressed or induced trips.

4.4.2 Severance Reduction Over Time

The U.K. guidelines recognised that the severance imposed by a new road had clear immediate consequences on existing patterns of movement. Over a period of time, the pattern of activities and communication linkages would alter to a new equilibrium possibly with accompanying changes in land value. Some of the travel across the barrier would be substituted by travel to other destinations, or by some trip suppression, or by eventual changes in land use. The residual ongoing costs of severance once these changes had taken place would be less than the immediate costs, but would not necessarily be negligible. In an extreme case, an island of land formed by severance could completely and indefinitely lose any practical value.

One could take the view that, while the obvious effects of severed communications will become less evident as the community adjusts to the change, there is still an enduring net loss in the functioning of the community through the lost opportunities caused by the barrier.

If the reverse situation is considered, the relief of barrier effect through provision of an urban by-pass, then the argument that severance effects become insignificant over time should logically work in reverse. While the community has functioned with the disadvantage of a high traffic flow through the town centre, there is still an improvement to the cohesion of the community by removal of the barrier which goes beyond merely the removal of noise, pollution and accidents.

4.4.3 Measuring and Predicting Changes to Cross-Barrier Flows

Quantifying the effects of severance is likely to be very data intensive. At the least, pedestrian crossing surveys are required, or a reliable method of estimation used, in the absence of measured data. While some pedestrian movement data may have been collected when assessing needs for pedestrian crossings and pedestrian phases at intersections, in most cases it is likely that the analyst will be faced with the need to conduct some form of survey. This will add to the resources required for the analysis of any proposed improvement project and there will be a desire that the cost of the survey and analysis does not become out of proportion with the social cost being accounted through severance effect.

There is also the difficulty of predicting the change in pedestrian crossing movements from an increase or decrease in the barrier effect. A gross measure of crossing movements without any disaggregation into the different groups in the community who are affected ignores the relative impacts on children, the aged and the incapacitated. These vulnerable groups require more time to cross the road and the disbenefits are likely to be greater (whether to the individuals themselves or to their care-givers). Differences in the valuation of time delays and savings for these groups have shown up clearly in research on the value of travel time, and particularly so in walking to and waiting for transport. There is a good case for distinguishing these groups in any survey work that may be undertaken.

Also, to measure crossing movement without any knowledge of the purpose or origins and destinations of trips makes it difficult to estimate the demand elasticity of cross-road movement. If the purpose of a trip can be readily satisfied by transfer to another destination, then the demand elasticity may be low, and the effect of the barrier in reducing this cross-movement will be high. If there are few alternative substitutes to the travel demand, then the demand will be less elastic and the pedestrian will endure a longer wait and more stress to achieve the crossing

Assessing relief of severance, such as the removal of traffic from an urban centre by construction of a by-pass, poses a more difficult problem. In this case, the removal of the traffic stream permits the establishment of communications across a route where this was previously difficult. It would require a forecast of the developed pedestrian and cycle traffic across the road, as well as the additional easing of existing movements, to enable an evaluation to be made on the basis of trip-making.

4.4.4. Distribution of Costs within the Community

Even if some trips can be readily diverted to other destinations, so the overall disruption cost to the community is less than if there was no such diversion opportunity, the distributional effects on individual groups may still be high. A retailer cut off from customers by a road could individually suffer a severe impact, even if clientele are able to satisfy their shopping needs elsewhere with relatively little reduction in choice. There are of course other effects of road bypasses on retailing, such as the potential loss of catch trade, and the balance of benefit will depend on the overall accessibility of the premises (in terms of getting to and stopping at the premises) to both pedestrian and motor traffic.

There are various other reasons why the effect on movement patterns of particular groups may be important in the analysis. School catchments and the flows of child pedestrians and cyclists are another group which may require special emphasis in an analysis.

4.4.5 Effects on Accessibility to Motor Vehicles

While not strictly part of the severance effect, a traffic barrier such as a main road with high traffic flows and limited side access can also limit the accessibility to adjacent land use by motor vehicles. Removal of the traffic flow and an increase in the local access function of the road can improve the accessibility of these adjacent premises. While these effects should be incorporated within the calculation of road user savings, there is the possibility that they may be overlooked. In some overseas evaluation procedures a specific method is provided to quantify these effects.

4.4.6 Severance and Urban Road and Traffic Planning in General

The existence or creation of a traffic or physical barrier to movement and communication is evidence of a conflict in the physical layout of the urban area. While crossing and parallel flows of pedestrians, cyclists, goods vehicles and other motor traffic in an urban area is inevitable, the physical layout of the street pattern, the arrangement and densities of land use, and the natural topography will lead to more or less movement conflicts. Urban planning can go some way to resolving these conflicts.

The view could be taken that to quantify and value severance effects could become a mechanical process which does not encourage the analyst to consider wider issues of urban land use and transport planning, or local area traffic management. It also raises the question of performance standards and to what extent severance should be merely acknowledged as a social cost rather than an effect to be mitigated.

The counter argument is that quantification will identify the magnitude of the social costs incurred and so will be useful in determining what level of mitigation can be justified and will therefore encourage the pursuit of imaginative solutions. It should be remembered that the project evaluation process is not a substitute for professional creativity in developing ways of improving the transport system, but a way of assessing project ideas once they have been formulated. It should strive to provide an evaluation framework which recognises the full range of community costs and benefits and provides a rational, acceptable and transparent method for ranking and selecting among alternatives.

4.5 A Possible Treatment of Severance Effects

4.5.1 Alternatives

The present guidelines on the treatment of severance are quite general. While identifying the issue they provide little real incentive or guidance to practitioners on how to go about an evaluation of severance or what likely weight severance may have in the overall evaluation framework. As the data needs may be high and not related directly to the roadway and road traffic, there will be an aversion to putting resources into data collection.

It is Transit New Zealand's objective to apply monetary values to intangible items in the analysis where it is reasonable to do so. This approach has been taken in overseas jurisdictions with which New Zealand often compares its own methods and performance. The application of a monetary value is subject to uncertainty but does assist in achieving some serious recognition of the environmental effects, rather than relegating them to the category of unquantifiable costs and benefits which may lead to their weighting in the decision process being arbitrary or, at worst, to their being effectively ignored.

Some other countries have established procedures for quantifying severance costs of main roads through urban areas. Whether these procedures are diligently followed is not known and desirably should be investigated. It is clear that quantification will be greatly assisted by establishing a base of data and relationships between traffic flow characteristics and the delay and disutility provided by a barrier effect. There may be merit in undertaking surveys to generate this base information. It may be worthwhile to also undertake surveys to identify typical pedestrian trip rates and land use linkages within urban areas, so that pedestrian flows can be estimated from information on land use and population rather than having to undertake detailed movement surveys. It may be possible, through sufficient case studies, to arrive at ranges of effects and costs for typical situations which could be used to identify the general order of magnitude of severance impacts.

An alternative to a quantitative approach is to treat severance in a similar way as the U.K. Manual of Environmental Appraisal. Effects would be classed in some general scale such as "minor, moderate or severe". This would leave the relative weighting of severance in the comparative evaluation of costs as an indeterminate item, relying on the judgement of those involved in the assessment and ranking process.

Whether or not a quantitative approach is taken to severance, it appears important that the effects on different groups in the community not be lost in some aggregate dollar value or rating of severity. This is one particular intangible for which distributional effects are likely to be of importance and need to be carried through into the project evaluation summary.

It is noted that the Draft Project Evaluation Manual (Transit New Zealand May 1995) does not require any formal analysis of the distributional effects of projects, a change from previous practice.

4.5.2 Requirements for a Quantitative Approach to Severance

If the effects of severance are to be estimated from the changes in travel cost for pedestrians (and possibly cyclists) then the information requirements will be as follows (for pedestrian trips which are not redistributed, suppressed or induced by changes in the barrier effect):

- Time to cross the roadway including walking/cycling along the road edge on either side of the road, waiting time and time actually crossing.

- Values of travel time savings (VTSS) for each of these elements of the pedestrian trip, which will vary according to age/ability and the nature of the roadway and traffic (induced level of stress). The VTTS as defined here will include perceived risk and intimidation.

- Numbers of trips made by each population group.

If the effects of trip suppression, induction and redistribution are to be incorporated, there is a need for some research-based empirical relationships between numbers of road crossings by pedestrians and the time cost of crossing. It may be possible to express the numbers of inhibited road crossings as a relative percentage of the number of crossings for a road where the traffic stream and road width pose no impediment to pedestrian traffic (that is where pedestrians can cross at will without having to wait or walk to a crossing point). These relationships may have to take account of the possibilities for substitution of the cross-road trip with a trip to another destination which is not faced by a barrier, that is the elasticity of demand for trips across the roadway.

As noted above, there would be an advantage in minimising the costs and time for the analysis of severance, if it were possible to estimate the demand for pedestrian movement from data on population and land use, probably by segmenting the demand into types of trip, determining typical trip rates and mapping local origins and destinations. At a more general level, trip numbers (road crossings) could possibly be estimated coarsely using a "gravity model" type of approach similar to that used by the Danish Roading Directorate where trip numbers are based on the intensities of land use on each side of the road and inversely against the crossing impedance.

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APPENDIX

- VALUATION DATA FOR PILOT SAMPLE
- TYPICAL FIELD SURVEY SHEET
- VALUATION NEW ZEALAND PROPERTY VALUE DATA
- PILOT CONTINGENT VALUATION QUESTIONNAIRE

VALUATION DEPT DATA FOR PILOT SAMPLE

Street	No.	Street Type	Date of Sale	Price $	Government Valuation Date	Capital	Land	Land Area	Floor Area	Age	Walls Type	Walls Cond	Roof Type	Roof Cond
BALL PL	6	X	08/07/89	130,000	01/07/87	90,000	38,000	675	110	1965	W	A	S	A
BALL PL	9	X	08/12/89	170,000	01/07/87	112,500	40,500	698	150	1965	W	G	T	G
BALL PL	12	X	22/01/89	147,000	01/07/87	92,500	37,000	761	110	1965	W	A	S	A
BANNISTER PL	3	X	21/06/89	220,000	01/05/89	215,000	39,500	1217	220	1965	W	G	S	G
BANNISTER PL	10	X	18/06/91	120,000	01/05/89	122,500	44,500	865	100	1965	W	G	S	A
BARKES PL	5	X	22/05/89	140,000	01/07/87	92,500	37,000	878	130	1965	W	A	S	A
BATTERSBY AVE	1	X	12/08/91	90,000	01/07/87	77,500	31,500	665	100	1965	B	F	T	A
BATTERSBY AVE	7	X	26/09/90	106,500	01/07/87	90,000	31,000	577	90	1965	F	G	T	A
BATTERSBY AVE	22	X	28/02/90	106,500	01/07/87	92,500	37,500	675	120	1965	W	A	T	A
BATTERSBY AVE	30	X	16/12/88	108,000	01/07/87	87,500	37,000	675	110	1965	W	A	S	A
BATTERSBY AVE	36	X	22/05/89	117,000	01/07/87	92,500	36,000	667	130	1965	W	A	S	A
BATTERSBY AVE	38	X	06/06/90	115,000	01/07/87	90,000	37,500	837	130	1965	W	A	S	A
BLOCKHOUSE BAY RD	256	M	09/09/88	89,000	01/07/85	57,000	28,000	607	80	1945	C	G	S	A
BLOCKHOUSE BAY RD	279	M	06/03/90	140,000	01/05/89	142,500	69,000	1012	130	1935	W	G	S	G
BLOCKHOUSE BAY RD	296	M	23/09/91	128,000	01/05/89	127,500	61,000	1214	130	1955	B	A	S	A
BLOCKHOUSE BAY RD	304	M	11/03/90	112,000	01/05/89	122,500	53,000	839	80	1955	W	G	S	G
BLOCKHOUSE BAY RD	319	M	28/03/89	76,000	01/05/89	95,000	43,000	647	120	1915	W	A	S	F
BLOCKHOUSE BAY RD	320	M	24/07/89	110,000	01/05/89	110,000	49,500	868	90	1955	W	A	T	A
BLOCKHOUSE BAY RD	329	M	18/07/89	113,000	01/05/89	135,000	50,000	860	170	1955	W	G	T	G
BLOCKHOUSE BAY RD	331	M	28/12/89	100,000	01/05/89	125,000	50,000	804	120	1955	W	A	S	A
BLOCKHOUSE BAY RD	352	M	08/11/88	105,000	01/05/89	115,000	63,000	956	110	1955	W	A	T	A
BLOCKHOUSE BAY RD	376	M	16/03/89	200,000	01/05/89	210,000	55,000	1649	300	1955	S	A	S	A
BLOCKHOUSE BAY RD	379	M	03/03/92	124,000	01/05/89	135,000	59,000	1012	90	1945	W	G	T	G
BLOCKHOUSE BAY RD	398	M	20/06/91	114,000	01/05/89	140,000	46,000	809	140	1955	B	A	S	A
BLOCKHOUSE BAY RD	404	M	31/07/91	144,500	01/05/89	135,000	51,000	804	110	1945	M	A	M	A
BLOCKHOUSE BAY RD	441	M	21/04/92	152,000	01/05/89	140,000	59,000	1152	120	1955	B	A	S	A
BLOCKHOUSE BAY RD	443	M	21/05/92	138,000	01/05/89	147,500	59,000	1152	130	1945	B	G	T	G
BLOCKHOUSE BAY RD	480	M	12/01/90	138,000	01/05/89	132,500	51,000	753	120	1965	B	G	T	G
BLOCKHOUSE BAY RD	486	M	01/05/92	173,000	01/05/98	190,000	52,000	769	170	1955	M	A	M	A
BLOCKHOUSE BAY RD	494	M	19/02/92	138,000	01/05/89	140,000	48,000	794	130	1955	W	A	T	A
BLOCKHOUSE BAY RD	500	M	17/03/89	111,750	01/05/89	102,500	59,000	974	100	1925	W	A	S	A
BOUNDARY RD	1	S	22/10/88	123,000	01/05/89	127,500	41,500	817	160	1955	W	A	S	A
BOUNDARY RD	13	S	25/05/89	130,000	01/05/89	155,000	47,000	612	110	1965	W	A	S	A
BOUNDARY RD	34	S	14/07/89	176,000	01/07/87	125,000	34,500	658	210	1965	M	A	T	G
BOUNDARY RD	50	S	24/04/89	109,000	01/07/87	90,000	35,500	759	100	1965	W	A	S	A
BOUNDARY RD	52	S	24/04/91	120,000	01/07/87	102,500	35,500	640	160	1965	W	A	T	A
BOUNDARY RD	55	S	20/03/90	160,000	01/05/89	125,000	41,500	612	110	1965	B	A	S	A
BOUNDARY RD	69	S	26/10/88	171,000	01/05/89	160,000	48,000	610	180	1965	M	A	T	A
BOUNDARY RD	85	S	26/08/89	141,000	01/05/89	140,000	52,000	617	130	1975	W	G	S	G
BOUNDARY RD	103	S	20/03/91	134,000	01/05/89	125,000	54,000	1264	110	1955	B	A	T	A
BOUNDARY RD	111	S	26/08/91	157,000	01/05/89	117,500	43,500	926	180	1955	W	A	S	F
BOUNDARY RD	144	S	30/11/90	125,000	01/07/87	75,000	44,500	935	70	1955	W	A	T	A
CLELAND CRESC	3	L	19/09/88	151,500	01/07/85	83,000	29,000	809	160	1955	B	G	T	A
CLELAND CRESC	15	L	31/10/88	135,000	01/05/89	137,500	46,000	860	140	1955	B	A	T	A
CLELAND CRESC	19	L	01/05/89	149,000	01/05/89	147,500	47,000	984	130	1955	B	A	S	A
CLELAND CRESC	21	L	11/06/89	164,000	01/05/89	150,000	45,500	1143	220	1955	W	A	S	A
CRECY PL	3	X	23/08/90	146,000	01/05/89	142,500	45,500	607	180	1975	M	A	T	A
CRECY PL	7	X	02/10/89	210,000	01/05/89	195,000	45,500	612	210	1975	W	G	T	G
CRECY PL	9	X	09/09/90	168,500	01/05/89	160,000	44,500	625	200	1965	W	A	T	A
CRECY PL	11	X	28/06/90	143,000	01/05/89	140,000	47,000	1095	130	1975	W	G	T	G
CRECY PL	17	X	11/08/89	215,000	01/05/89	190,000	44,500	660	170	1965	W	G	T	G
CRUDGE ST	5	L	05/11/91	195,000	01/05/89	190,000	56,000	890	210	1965	B	A	S	A
DALLAS PL	10	X	15/09/88	135,000	01/07/85	74,000	25,000	607	140	1975	F	G	S	G
DALLAS PL	15	X	13/08/90	164,000	01/05/89	150,000	43,000	630	170	1975	B	G	T	G
DALLAS PL	19	X	24/09/89	156,000	01/05/89	150,000	43,000	620	140	1975	B	G	T	G
DALLAS PL	21	X	19/06/90	152,000	01/05/89	145,000	43,000	610	160	1975	W	A	T	G
DALLAS PL	30	X	18/09/89	148,000	01/05/89	160,000	43,000	610	150	1975	F	G	T	G
DONOVAN ST	44	M	14/01/92	143,000	01/05/89	146,000	60,000	733	190	1955	B	G	T	G
DONOVAN ST	45	M	04/10/89	110,000	01/05/89	115,000	52,000	675	80	1925	W	A	S	A
DONOVAN ST	49	M	22/09/88	145,000	01/05/89	150,000	55,000	751	190	1955	W	A	S	A
DONOVAN ST	75A	M	30/03/92	120,000	01/05/89	140,000	50,000	546	220	1965	W	A	T	A
DONOVAN ST	83	M	08/09/88	109,000	01/07/85	59,000	40,000	960	80	1955	W	A	A	A
DONOVAN ST	88	M	23/08/89	130,000	01/05/89	130,000	60,000	809	120	1955	W	A	T	A
DONOVAN ST	112	M	29/04/92	186,000	01/05/89	195,000	58,000	607	260	1965	B	G	T	G
DONOVAN ST	123	M	28/07/90	123,000	01/05/89	125,000	65,000	1012	100	1925	W	A	S	A
DONOVAN ST	127	M	06/05/89	219,000	01/05/89	65,000	65,000	1011	210	1985	M	G	M	G
DONOVAN ST	133	M	20/01/92	119,000	01/05/89	135,000	59,000	1019	120	1950	W	A	S	A
DUNDALE AVE	5	L	11/12/89	113,000	01/05/89	107,500	44,500	1244	120	1915	W	F	S	A
DUNDALE AVE	17	L	12/12/89	110,000	01/05/89	115,000	43,000	1148	120	1965	S	A	T	A

VALUATION DEPT DATA FOR PILOT SAMPLE

Street	No.	Street Type	Date of Sale	Price $	Government Valuation Date	Capital	Land	Land Area	Floor Area	Age	Walls Type	Walls Cond	Roof Type	Roof Cond
DUNDALE AVE	19	L	22/03/89	90,000	01/05/89	112,500	41,500	607	90	1965	W	A	S	A
DUNDALE AVE	37	L	24/02/89	110,500	01/05/89	110,000	41,500	614	100	1965	W	A	S	A
DUNDALE AVE	61	L	31/01/89	135,000	01/05/89	100,000	53,000	1362	130	1905	W	A	S	P
DUNDALE AVE	85	L	27/04/92	80,000	01/05/89	102,500	44,500	845	80	1955	W	A	S	A
DUNDALE AVE	89	L	27/08/91	114,000	01/05/89	125,000	43,000	809	130	1965	W	A	S	A
DUNDEE PL	3	X	23/09/89	150,000	01/05/89	145,000	39,000	792	200	1965	B	A	T	A
DUNDEE PL	5	X	14/06/90	126,000	01/05/89	122,500	39,000	721	130	1965	W	A	T	A
DUNDEE PL	15	X	10/06/90	195,000	01/05/89	170,000	48,500	708	150	1965	W	A	T	A
DUNDEE PL	16	X	23/12/89	126,000	01/05/89	125,000	46,000	673	120	1965	W	A	T	A
DUNDEE PL	18	X	15/10/89	138,000	01/05/89	125,000	45,500	635	130	1965	W	A	S	A
DUNDEE PL	25	X	14/02/92	114,000	01/05/89	120,000	46,000	612	100	1965	W	A	S	A
DUNDEE PL	32	X	03/11/89	140,000	01/05/89	130,000	45,500	1148	160	1965	W	A	S	A
DUNDEE PL	33	X	25/06/91	110,000	01/05/89	135,000	40,500	627	140	1965	W	A	S	A
DUNDEE PL	38	X	22/02/89	133,000	01/05/89	125,000	42,000	612	110	1965	B	A	T	A
DUNDEE PL	44	X	23/05/92	100,000	01/10/91	115,000	47,500	667	90	1965	W	A	T	A
DUNDEE PL	58	X	10/03/92	112,000	01/05/89	122,500	46,000	1110	120	1960	W	A	S	A
DUNDEE PL	66	X	13/09/91	123,000	01/05/89	115,000	41,500	693	110	1965	W	A	S	A
DUNDEE PL	68	X	15/01/89	150,000	01/05/89	155,000	40,500	665	120	1965	W	A	S	A
DUNDEE PL	70	X	27/10/90	133,000	01/05/89	120,000	39,500	637	190	1965	W	A	S	A
DUNDEE PL	72	X	22/09/89	140,000	01/05/89	137,500	38,000	766	180	1965	W	A	S	A
ELLIS AVE	8	D	04/11/91	97,000	01/07/87	80,000	35,500	825	120	1955	W	A	S	A
ELLIS AVE	10	D	27/07/91	131,000	01/07/87	95,000	35,500	835	150	1955	W	A	S	F
ELLIS AVE	16	D	07/06/92	114,000	01/10/91	105,000	55,000	830	130	1955	W	A	S	A
ELLIS AVE	29	D	23/11/91	86,000	01/07/87	77,500	41,000	868	80	1955	W	A	S	A
ELLIS AVE	30	D	19/04/92	123,000	01/07/87	115,000	31,500	819	200	1965	W	A	S	G
ELLIS AVE	33	D	08/11/88	115,000	01/07/87	82,500	46,000	852	80	1955	W	A	S	A
ELLIS AVE	38	D	28/07/92	128,000	01/10/91	125,000	50,000	817	140	1965	W	A	S	A
ELLIS AVE	39	D	23/06/90	90,500	01/07/87	80,000	31,000	885	100	1965	B	A	S	A
ELLIS AVE	45	D	11/07/89	128,500	01/07/87	92,500	45,000	794	110	1955	W	A	S	A
ELLIS AVE	54	D	19/09/88	134,000	01/07/87	107,500	35,500	877	200	1965	W	A	S	A
ELLIS AVE	61	D	26/09/90	128,000	01/07/87	90,000	39,500	675	100	1965	W	A	S	A
EXMINSTER ST	11	L	14/08/90	228,000	01/05/89	180,000	59,000	667	300	1965	B	A	T	A
EXMINSTER ST	20	L	21/12/88	140,000	01/05/89	140,000	65,000	784	160	1925	W	A	S	A
EXMINSTER ST	24	L	25/08/89	157,000	01/05/89	165,000	54,000	723	150	1965	W	A	T	A
EXMINSTER ST	28	L	26/05/92	128,000	01/05/89	140,000	49,500	726	130	1965	W	A	T	A
EXMINSTER ST	49	L	28/02/89	222,000	01/05/89	175,000	53,000	698	100	1955	W	A	T	A
GRAHAM BELL	15	L	15/02/91	95,000	01/07/87	70,000	35,500	809	80	1955	W	A	S	A
GRAHAM BELL	16	L	22/04/92	105,000	01/07/87	85,000	40,500	857	100	1955	W	A	T	A
GRAHAM BELL	17	L	01/12/89	108,000	01/07/87	85,000	35,500	809	80	1965	B	A	S	A
GRAHAM BELL	29	L	29/01/91	160,500	01/07/87	100,000	37,000	809	200	1955	W	A	S	A
GENEVA PL	3	X	12/12/90	138,000	01/05/89	130,000	49,500	809	110	1955	A	A	T	A
GENEVA PL	9	X	23/03/91	166,000	01/05/89	175,000	49,500	1007	390	1965	M	F	S	F
GENEVA PL	10	X	19/12/88	145,000	01/05/89	145,000	46,000	809	100	1965	W	G	T	G
GENEVA PL	12	X	17/06/92	162,000	01/10/91	145,000	52,500	809	140	1965	W	G	S	G
GENEVA PL	23	X	06/01/90	128,000	01/05/89	122,500	47,000	819	100	1965	W	A	S	A
GENEVA PL	33	X	01/08/89	129,000	01/05/89	127,500	48,000	1042	140	1965	W	A	S	A
GENEVA PL	37	X	30/07/92	138,000	01/10/91	120,000	50,000	809	130	1965	W	A	S	A
HAYCOCK AVE	1	L	02/10/89	124,000	01/07/87	115,000	37,000	675	180	1965	W	A	S	A
HAYCOCK AVE	16	L	31/03/89	135,000	01/07/87	90,000	35,000	675	100	1965	W	A	S	A
HAYCOCK AVE	22	L	05/04/90	119,000	01/07/87	90,000	33,500	673	120	1965	W	G	S	G
HAYCOCK AVE	24	L	28/06/89	105,000	01/07/87	90,000	33,500	675	120	1965	W	A	S	F
HAYCOCK AVE	26	L	19/12/88	106,600	01/07/87	82,500	33,500	675	80	1965	W	A	S	A
HAYCOCK AVE	28	L	03/01/89	124,500	01/07/87	87,500	33,500	690	100	1965	W	G	S	G
HAYCOCK AVE	33	L	30/01/90	141,000	01/07/87	92,500	36,000	675	120	1965	W	G	S	G
HAYCOCK AVE	34	L	04/02/91	120,500	01/07/87	90,000	31,500	675	130	1965	W	G	S	A
HAYCOCK AVE	44	L	10/07/90	112,000	01/07/87	90,000	33,500	673	90	1965	W	G	T	A
HAYCOCK AVE	51	L	14/09/91	144,000	01/07/87	97,500	37,000	701	140	1975	M	A	S	A
HAYCOCK AVE	53	L	09/01/90	161,000	01/07/87	145,000	41,000	657	150	1975	W	A	T	A
HAYCOCK AVE	58	L	08/02/91	176,000	01/07/87	127,500	35,000	1176	200	1975	M	A	T	A
HERTFORD ST	4	L	11/05/90	105,000	01/05/89	105,000	365,000	969	110	1965	W	A	S	A
HERTFORD ST	7	L	15/02/89	114,000	01/05/89	115,000	43,000	1201	100	1955	M	A	T	A
HERTFORD ST	9	L	09/02/89	97,700	01/05/89	107,500	39,500	837	80	1955	W	A	T	A
HERTFORD ST	15	L	13/06/89	110,200	01/05/89	110,000	40,500	837	110	1955	W	A	T	A
HERTFORD ST	20	L	09/05/90	110,500	01/05/89	110,000	48,000	847	90	1955	W	A	T	A
HERTFORD ST	23	L	17/10/88	117,700	01/07/85	61,000	25,000	905	100	1955	F	A	T	A
HERTFORD ST	24	L	30/08/90	157,000	01/05/89	120,000	56,000	2195	80	1950	W	A	S	A
HERTFORD ST	30	L	04/10/89	100,000	01/05/89	105,000	47,000	1002	80	1925	W	A	S	A
HERTFORD ST	32	L	16/12/88	103,000	01/05/89	107,500	49,500	1002	110	1920	M	A	S	A
HERTFORD ST	36	L	30/01/90	87,000	01/05/89	110,000	48,500	1014	100	1945	R	A	T	F

VALUATION DEPT DATA FOR PILOT SAMPLE

Street	No.	Street Type	Date of Sale	Price $	Government Valuation Date	Capital	Land	Land Area	Floor Area	Age	Walls Type	Walls Cond	Roof Type	Roof Cond
HOLBROOK ST	18	L	01/12/88	134,000	01/05/89	132,500	41,500	799	120	1965	W	A	S	A
HOLBROOK ST	19	L	04/09/89	86,000	01/05/89	105,000	44,500	839	80	1955	W	A	T	A
HOLBROOK ST	20	L	06/01/89	120,000	01/05/89	130,000	44,500	1318	140	1965	W	A	S	F
HOLBROOK ST	23	L	13/09/88	111,500	01/07/85	73,000	29,000	974	100	1955	W	A	T	A
HOLBROOK ST	25	L	09/03/89	139,000	01/05/89	142,500	49,500	884	150	1975	F	A	T	A
HOLBROOK ST	28	L	29/06/89	122,000	01/05/89	117,500	41,500	1244	120	1955	F	A	T	A
HOLBROOK ST	36	L	16/06/89	117,200	01/05/89	127,500	43,000	1095	170	1955	B	F	S	F
HOLBROOK ST	37	L	07/02/92	95,000	01/05/89	117,500	40,500	809	100	1955	W	A	S	A
HOLBROOK ST	39	L	07/02/90	100,000	01/05/89	117,500	41,500	809	100	1955	W	A	S	A
HOLBROOK ST	41	L	23/11/90	90,000	01/05/89	120,000	48,000	900	110	1955	W	A	S	A
HOLBROOK ST	42	L	15/03/89	102,400	01/05/89	105,000	39,500	622	100	1955	F	A	T	A
HOLBROOK ST	43	L	22/06/90	104,000	01/05/89	115,000	44,500	830	90	1955	W	A	S	A
HOLBROOK ST	56	L	14/11/89	120,000	01/05/89	122,500	43,000	1067	110	1965	W	A	T	A
HOLBROOK ST	62	L	20/11/91	127,500	01/05/89	145,000	41,500	612	180	1960	W	A	T	A
HOLBROOK ST	70	L	17/10/90	113,000	01/05/89	120,000	39,500	657	120	1965	W	A	S	A
HUMBER PL	4	X	10/07/91	133,000	01/05/89	122,500	41,500	620	140	1965	W	A	S	A
HUMBER PL	9	X	23/06/89	129,000	01/05/89	122,500	36,500	1394	170	1965	W	A	T	A
HUMBER PL	12	X	29/10/91	172,000	01/05/89	155,000	43,000	625	270	1965	B	G	S	A
JAMAICA PL	1	X	08/08/91	118,000	01/05/89	125,000	49,500	607	120	1965	W	A	S	A
JAMAICA PL	5	X	29/07/92	97,500	01/10/91	110,000	47,500	607	90	1965	W	A	S	A
JAMAICA PL	9	X	17/04/90	107,000	01/05/89	115,000	46,000	607	80	1965	W	A	S	A
JAMAICA PL	15	X	05/06/90	110,000	01/05/89	127,500	48,000	1090	130	1965	W	A	S	A
JAMAICA PL	24	X	06/03/91	106,000	01/05/89	117,500	38,000	604	100	1965	F	A	S	A
JAMAICA PL	26	X	07/02/90	100,000	01/05/89	112,500	41,500	885	90	1965	M	A	T	A
JAMAICA PL	30	X	07/11/91	101,000	01/05/89	120,000	41,500	617	100	1965	W	A	S	A
JOHN DAVIS RD	8	D	07/05/92	149,000	01/10/91	160,000	67,500	675	160	1965	B	G	T	G
JOHN DAVIS RD	13	D	08/01/89	134,500	01/07/87	107,500	44,500	658	180	1965	W	A	S	A
JOHN DAVIS RD	14	D	28/11/88	192,500	01/07/87	145,000	43,500	690	190	1965	B	G	T	A
JOHN DAVIS RD	16	D	24/08/91	179,000	01/07/87	180,000	46,500	672	330	1965	B	G	T	G
JOHN DAVIS RD	22	D	22/11/89	128,000	01/07/87	95,000	35,000	688	100	1965	W	G	T	A
JOHN DAVIS RD	27	D	23/01/91	204,000	01/07/87	145,000	47,000	703	180	1975	B	G	T	G
JOHN DAVIS RD	40	D	13/02/90	118,000	01/07/87	90,000	37,000	693	90	1965	W	A	S	A
JOHN DAVIS RD	57	D	17/05/89	137,000	01/07/87	95,000	34,000	680	90	1965	W	A	S	A
JOHN DAVIS RD	77	D	01/10/88	122,000	01/07/87	95,000	35,500	756	100	1965	W	G	S	G
JOHN DAVIS RD	79	D	13/07/90	126,000	01/07/87	90,000	36,000	804	100	1965	W	A	S	A
LABURNUM RD	8	L	21/11/89	141,800	01/05/89	125,000	43,500	610	130	1965	W	A	S	A
LABURNUM RD	11	L	18/04/89	122,000	01/05/89	130,000	42,000	632	120	1965	W	A	S	A
LABURNUM RD	18	L	26/06/90	138,000	01/05/89	135,000	45,500	890	130	1965	B	G	T	G
LABURNUM RD	23	L	03/11/90	106,000	01/05/89	107,500	43,000	708	90	1965	W	A	S	A
LABURNUM RD	24	L	21/11/91	114,500	01/05/89	120,000	43,500	696	120	1965	W	A	S	A
LABURNUM RD	29	L	03/06/90	123,000	01/05/89	130,000	43,500	731	140	1965	W	A	S	A
LABURNUM RD	31	L	07/12/88	117,500	01/05/89	125,000	38,000	673	120	1965	W	A	S	A
LABURNUM RD	33	L	18/11/89	130,500	01/05/89	125,000	37,000	711	130	1965	W	A	S	A
LABURNUM RD	37	L	25/01/89	128,000	01/05/89	127,500	38,000	635	110	1965	W	A	S	A
LABURNUM RD	43	L	17/10/90	131,000	01/05/89	115,000	40,500	658	120	1965	W	A	T	A
LABURNUM RD	45	L	23/11/90	124,000	01/05/89	130,000	48,000	743	120	1965	W	A	S	A
LETTERKENNY PL	16	X	30/04/92	154,000	01/05/89	185,000	55,000	1095	250	1965	W	A	S	A
LETTERKENNY PL	46	X	21/05/91	248,000	01/05/89	325,000	60,000	982	430	1965	B	G	T	G
MCFADZEAN DR	6	L	19/02/91	157,000	01/05/89	140,000	48,000	607	160	1965	W	G	T	G
MCFADZEAN DR	16	L	08/04/92	148,000	01/05/89	160,000	56,000	1338	190	1965	W	G	S	G
MCFADZEAN DR	24	L	05/05/92	137,000	01/05/89	142,500	48,500	607	130	1965	W	G	S	G
MCFADZEAN DR	26	L	24/10/88	170,000	01/05/89	175,000	48,000	607	190	1965	W	G	S	G
MCFADZEAN DR	27	L	28/11/89	205,000	01/05/89	185,000	54,000	607	150	1965	B	G	T	G
MCFADZEAN DR	39	L	26/05/90	228,000	01/05/89	200,000	55,000	782	240	1965	W	A	T	A
MCFADZEAN DR	40	L	02/09/91	130,000	01/05/89	137,500	48,500	607	150	1965	W	A	S	A
MCFADZEAN DR	42	L	04/11/88	156,000	01/05/89	160,000	48,000	607	180	1965	W	G	S	G
MCFADZEAN DR	43	L	20/07/91	176,000	01/05/89	185,000	56,000	680	210	1965	B	G	T	G
MCFADZEAN DR	44	L	25/09/88	145,000	01/05/89	147,500	48,000	620	150	1965	W	G	T	G
MCFADZEAN DR	46	L	04/08/91	138,000	01/05/89	150,000	56,000	1179	140	1965	W	G	S	G
MCFADZEAN DR	60	L	15/06/89	165,000	01/05/89	170,000	48,500	875	180	1965	B	G	T	G
MCFADZEAN DR	70	L	31/03/89	219,000	01/05/89	170,000	50,000	875	190	1965	B	G	T	G
MCLAURIN ST	9	X	10/01/90	205,000	01/05/89	190,000	48,000	817	170	1975	B	G	T	G
MCLAURIN ST	19	X	20/01/89	167,500	01/05/89	170,000	54,000	683	140	1965	B	G	T	A
MCLAURIN ST	23	X	18/07/89	184,500	01/05/89	190,000	47,500	693	250	1965	B	G	S	G
MCLAURIN ST	44/44	X	11/07/92	233,000	01/10/91	170,000	52,500	1176	170	1965	W	G	S	A
MAIORO ST	38	M	05/02/92	87,500	01/05/89	115,000	46,000	961	130	1945	C	A	F	A
MAIORO ST	60A	M	06/06/92	159,000	01/10/91	160,000	52,500	1313	190	1965	W	A	S	A
MARCONI PL	1	X	15/11/91	143,000	01/05/89	130,000	43,000	720	170	1965	W	A	S	A
MARCONI PL	9	X	05/05/92	112,000	01/10/91	130,000	47,500	721	170	1965	W	A	S	A

VALUATION DEPT DATA FOR PILOT SAMPLE

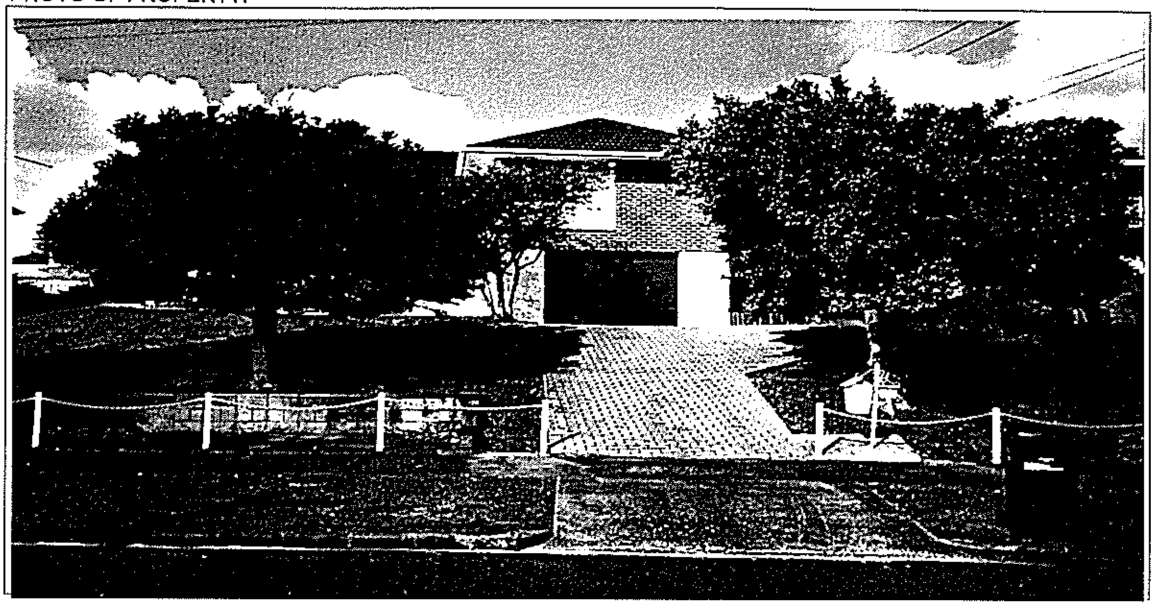
Street	No.	Street Type	Date of Sale	Price $	Government Valuation Date	Government Valuation Capital	Government Valuation Land	Land Area	Floor Area	Age	Walls Type	Walls Cond	Roof Type	Roof Cond
MARGATE RD	61	D	07/01/92	152,000	01/05/89	210,000	38,000	1189	240	1965	W	A	S	A
MARGATE RD	69	D	08/04/92	75,000	01/05/89	115,000	43,000	1151	110	1955	F	A	S	A
MARY DREAVER ST	50	D	23/07/92	98,000	01/10/91	105,000	45,000	622	110	1965	W	A	S	A
MARY DREAVER ST	60	D	04/03/92	124,000	01/05/89	136,000	49,500	1981	150	1965	E	A	S	A
MAUI POMARE ST	6	X	06/04/92	93,000	01/05/89	100,000	39,500	622	90	1965	W	A	S	A
MORPETH PL	11	X	21/08/92	136,000	01/10/91	130,000	45,000	650	170	1975	W	A	S	A
MORPETH PL	12	X	04/03/92	114,000	01/05/89	112,500	44,500	1153	120	1965	W	G	S	G
MULGAN ST	29	D	15/04/92	128,000	01/05/89	140,000	42,000	673	130	1965	W	A	S	A
MULGAN ST	36	D	15/06/92	124,000	01/10/91	120,000	50,000	675	130	1965	W	A	S	A
MULGAN ST	65	D	24/01/92	123,000	01/05/89	137,500	46,000	627	120	1965	W	A	S	A
NEW WINDSOR RD	96	M	03/12/91	103,000	01/05/89	100,000	48,000	809	80	1945	B	A	T	A
NEW WINDSOR RD	135	M	22/04/92	214,000	01/05/89	230,000	49,500	894	360	1975	B	G	T	G
NEW WINDSOR RD	196	M	09/10/91	86,000	01/05/89	105,000	47,000	850	110	1955	W	A	S	A
NEW WINDSOR RD	200	M	25/05/92	71,000	01/05/89	95,000	48,000	850	70	1955	W	A	T	A
NEW WINDSOR RD	256	M	12/09/91	109,000	01/05/89	127,000	33,000	1133	120	1995	E	G	S	G
NEW WINDSOR RD	268	M	10/03/92	112,000	01/05/89	115,000	39,000	1085	140	1965	W	A	S	A
PASTEUR PL	19	X	07/11/91	128,000	01/05/89	132,500	46,000	731	120	1975	M	G	T	G
PENBURY PL	3	X	15/02/92	171,000	01/05/89	160,000	48,000	794	170	1975	B	G	T	G
PETER BUCK RD	11	L	11/12/91	95,000	01/05/89	110,000	41,500	652	90	1965	W	A	S	A
PETER BUCK RD	35	L	17/11/91	154,000	01/05/89	155,000	43,000	624	170	1965	W	G	T	G
RICHARDSON RD	88	M	08/08/92	118,000	01/10/91	125,000	60,000	809	120	1955	W	A	S	A
RICHARDSON RD	122	M	20/12/91	114,000	01/07/86	97,500	50,000	1133	120	1955	F	A	T	A
RICHARDSON RD	173	M	15/05/92	75,000	01/05/89	102,500	57,000	903	70	1955	W	A	S	A
RICHARDSON RD	191	M	26/07/92	86,000	01/10/91	95,000	47,500	718	80	1955	W	A	S	A
RICHARDSON RD	253	M	10/01/92	109,000	01/05/89	117,500	48,500	667	90	1955	W	A	S	A
RICHARDSON RD	358	M	14/03/92	126,000	01/07/87	92,500	35,000	890	130	1965	W	A	S	A
RICHARDSON RD	380	M	01/03/92	126,000	01/07/87	115,000	47,500	845	180	1955	M	A	M	A
RICHARDSON RD	387	M	10/02/92	161,000	01/07/87	115,000	48,500	893	140	1955	B	G	T	A
SALLY CRESC	7	X	22/10/91	129,000	01/07/87	140,000	43,500	658	210	1965	W	G	T	F
SUBRITZKY AVE	18	L	16/11/91	121,000	01/07/87	102,500	29,500	885	260	1965	W	A	S	A
TEDWILLIAM ST	2	X	12/01/92	103,000	01/05/89	142,500	43,500	635	210	1965	W	F	S	A
TEDWILLIAM ST	37	X	25/04/92	122,000	01/10/91	125,000	45,000	953	140	1965	W	G	T	G
TERRY ST	17	D	09/10/91	247,000	01/05/89	210,000	43,500	751	260	1975	B	G	T	G
TIVERTON RD	11	M	18/11/91	102,000	01/05/89	102,500	53,000	809	80	1955	S	G	F	F
TIVERTON RD	70	M	26/06/92	115,000	01/10/91	125,000	52,500	1052	140	1965	W	A	T	A
TREVOLA ST	23	L	12/06/92	161,000	01/05/89	155,000	44,500	607	170	1975	W	G	T	G
TRINIDAD ST	41	L	01/11/91	124,000	01/05/89	130,000	41,500	766	100	1965	R	A	T	A
WAYNE PL	23	X	13/03/92	199,000	01/07/87	142,500	44,500	946	230	1965	W	G	S	G
WHITE SWAN RD	32	M	01/03/92	100,000	01/07/87	87,500	37,000	809	100	1955	W	A	T	A
WHITE SWAN RD	108	M	23/04/92	152,000	01/10/91	135,000	60,000	857	130	1955	W	A	S	A
WHITE SWAN RD	172	M	27/07/92	100,000	01/10/91	115,000	58,000	1318	130	1955	R	F	T	A
WHITNEY ST	31	D	26/02/92	99,000	01/05/89	130,000	38,000	1012	120	1975	W	A	T	G
WHITNEY ST	109	D	04/07/92	130,000	01/10/91	115,000	42,500	607	100	1965	W	A	S	A
WHITNEY ST	177	D	15/12/91	139,000	01/05/89	155,000	45,500	1173	170	1965	W	A	S	A
WHITNEY ST	196	D	07/05/92	150,000	01/05/89	170,000	48,000	1012	200	1955	W	A	T	A
WHITNEY ST	201	D	27/12/91	136,000	01/05/89	165,000	43,500	736	180	1965	W	A	S	A
WHITNEY ST	252	D	15/11/91	209,000	01/05/89	150,000	51,000	1370	190	1965	W	A	T	A
WHITNEY ST	268	D	20/09/91	167,000	01/05/89	165,000	50,000	1012	140	1955	W	A	T	A
WHITNEY ST	284	D	15/01/92	142,500	01/05/89	125,000	51,000	1012	190	1975	M	A	T	A

REDUCED DATA SET

STREET ADDRESS		Dependent Variable Property Price $	Street Value Factored Property Price $	Normalised Property Price per sq m	Normalised & Factored Property Price per sq m	Dervied Independent Variable				
						Floor Area	Facade dBA above Background	Section Area	Visual Intrusion Index	Distance from Traffic
DONOVAN ST	123	$124,399	$124,709	$1,244	$1,247	100	17.28	1012	0.75	12.50
DONOVAN ST	75A	$119,664	$119,961	$544	$545	220	16.71	546	0.81	14.00
DONOVAN ST	44	$142,599	$142,954	$751	$752	190	16.33	733	0.13	15.50
DONOVAN ST	133	$118,666	$118,962	$989	$991	120	16.30	1019	0.15	14.75
DONOVAN ST	88	$143,592	$143,949	$1,197	$1,200	120	15.66	809	0.11	17.00
DONOVAN ST	45	$119,400	$119,697	$1,492	$1,496	80	15.51	675	0.46	17.00
DONOVAN ST	49	$168,351	$168,770	$886	$888	190	15.08	751	0.11	17.50
BLOCKHOUSE BAY RD	486	$172,515	$166,178	$1,015	$978	170	14.97	769	0.18	13.00
BLOCKHOUSE BAY RD	494	$137,613	$132,558	$1,059	$1,020	130	14.20	794	0.35	15.25
WHITE SWAN RD	108	$151,574	$164,461	$1,166	$1,265	130	13.65	857	0.05	22.50
BLOCKHOUSE BAY RD	480	$147,246	$141,838	$1,227	$1,182	120	13.58	753	0.32	17.00
BLOCKHOUSE BAY RD	256	$103,333	$99,537	$1,292	$1,244	80	13.22	607	0.09	17.50
BLOCKHOUSE BAY RD	279	$149,380	$143,893	$1,149	$1,107	130	12.90	1012	0.07	20.00
BLOCKHOUSE BAY RD	319	$87,196	$83,993	$727	$700	120	12.57	647	0.12	19.75
BLOCKHOUSE BAY RD	379	$123,652	$119,111	$1,374	$1,323	90	11.56	1012	0.22	23.00
BLOCKHOUSE BAY RD	398	$113,521	$109,352	$811	$781	140	11.33	809	0.19	23.00
NEW WINDSOR RD	135	$213,400	$252,511	$593	$701	360	10.44	894	0.12	13.50
BLOCKHOUSE BAY RD	304	$119,504	$115,115	$1,494	$1,439	80	9.73	839	0.07	28.50
BOUNDARY RD	1	$141,959	$128,970	$887	$806	160	9.62	817	0.61	13.75
BLOCKHOUSE BAY RD	443	$137,613	$132,558	$1,059	$1,020	130	8.91	1152	0.08	31.50
BOUNDARY RD	85	$155,742	$141,492	$1,198	$1,088	130	8.89	617	0.47	15.50
BOUNDARY RD	111	$157,000	$142,635	$872	$792	180	8.73	926	0.13	15.00
BOUNDARY RD	55	$170,720	$155,100	$1,552	$1,410	110	8.47	612	0.40	15.50
BOUNDARY RD	34	$194,402	$176,614	$926	$841	210	8.26	658	0.11	16.50
BOUNDARY RD	103	$132,879	$120,721	$1,208	$1,097	110	7.51	1264	0.08	18.00
BOUNDARY RD	144	$125,176	$113,723	$1,788	$1,625	70	6.73	935	0.21	20.50
NEW WINDSOR RD	196	$85,759	$101,476	$780	$923	110	5.12	850	0.10	26.50
ELLIS AVE	54	$155,580	$163,212	$778	$816	200	4.93	877	0.65	11.75
WHITNEY ST	201	$135,619	$153,854	$753	$855	180	3.89	736	0.62	15.00
ELLIS AVE	61	$129,456	$135,807	$1,295	$1,358	100	3.54	675	0.55	14.25
WHITNEY ST	31	$98,722	$111,997	$823	$933	120	2.95	1012	0.08	18.25
ELLIS AVE	38	$127,641	$133,903	$912	$956	140	2.89	817	0.10	15.50
ELLIS AVE	30	$122,655	$128,672	$613	$643	200	2.79	819	0.10	15.75
ELLIS AVE	16	$113,680	$119,257	$874	$917	130	2.20	830	0.23	17.25
WHITNEY ST	268	$167,000	$189,455	$1,193	$1,353	140	1.57	1012	0.06	20.50
WHITNEY ST	196	$149,579	$169,692	$748	$848	200	1.46	1012	0.05	22.50
WHITNEY ST	177	$138,610	$157,248	$815	$925	170	1.03	1173	0.19	22.25
ELLIS AVE	29	$85,759	$89,966	$1,072	$1,125	80	0.59	868	0.03	24.00
ELLIS AVE	39	$93,979	$98,589	$940	$986	100	0.38	885	0.16	24.50

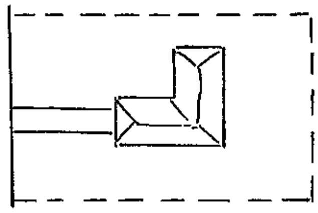
ADDRESS: 75 Somewhere Street

PHOTO OF PROPERTY:

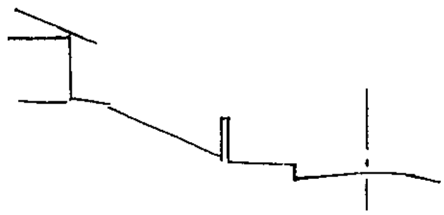


SKETCH OF SITE:

PLAN:



CROSS-SECTION:



ROAD WIDTH: 7 metres

FOOTPATH / VERGE WIDTH: 5 metres

OFF-STREET PARKING: **GARAGE** / CARPORT / DRIVEWAY / NONE **1** / 2 VEHICLES (circle)

LENGTH OF STREET FRONTAGE 15.5 metres

POSITION: **MID-BLOCK** / END OF BLOCK (circle)

ESTIMATED SET-BACK OF HOUSE FROM FRONT BOUNDARY: 11.5 Metres

ELEVATION OF PROPERTY w.r.t ROAD: V HIGH / **HIGH** / LEVEL / LOW / V LOW

COMPASS DIRECTION OF BUILDING FACE: W (N,NW,W,SW,S,SE,E,NE)

DISTANCE TO ADJACENT BUILDINGS: Left Side 4.5 metres Right Side 5 metres

TYPE OF FENCE: CHAIN

HEIGHT: **LOW** / MEDIUM / HIGH

GATEWAY: **OPEN** / GATED

OBSTRUCTIONS: Nil

INTERVENING VEGETATION: NONE / LIGHT / **MEDIUM** / HEAVY LOW / **MEDIUM** / HIGH

USES OF FRONT YARD: **ORNEMENTAL** / LIVING / UTILITY — **GOOD** / FAIR / POOR

LEVELS: **SINGLE** / 2 / 3

BASEMENT: **YES** / NO GARAGE

ROOF MATERIAL: STEEL / **TILE** / OTHER

CONDITION: **GOOD** / FAIR / POOR

WALLS: W'BOARD / **BRICK** / FIBRE CEMENT — **GOOD** / FAIR / POOR

WINDOWS: D. HUNG / **CASEMENT**

MATERIAL: **WOOD** / ALLOY

FACING WALL AREA ______ sq m

WINDOWS % ______

ENTRANCEWAY: **FACING** / SIDE

TABLE 5

Main Urban Categories by Total New Zealand

Freehold Open Market Sales

Half Year Ended		Dec 1988	June 1989	Dec 1989	June 1990	Dec 1990	June 1991
Houses							
Number of Sales		30 389	33 400	34 583	34 397	30 230	25 630
Average Sale Price	($)	97,867	107,005	112,578	115,500	114,752	114,255
House Price Index		N/A	N/A	1000	1055	1076	1067
Percentage Change		N/A	N/A	N/A	5.5	2.0	-0.8
Note: See Table 14 for historical series by total principal urban areas							
Owner-Occupied Flats							
Number of Sales		7 526	8 447	9 422	9 073	8 013	6 624
Average Sale Price	($)	94,588	101,749	104,628	107,843	106,933	105,005
Sections							
Number of Sales		3 656	4 561	4 439	5 046	4 297	4 109
Average Sale Price	($)	34,170	37,682	41,437	43,437	43,333	40,724
Purpose Built Flats							
Number of Blocks Sold		447	466	513	475	470	413
Average Sale Price	($)	183,545	188,025	205,356	201,373	201,058	187,710
Average No. Units Per Blk		3.4	3.4	3.5	3.4	3.5	4.4
Average Sale Price per Unit	($)	53,765	54,797	59,217	58,755	58,116	42,878
Houses Converted to Flats							
Number of Houses Sold		471	448	514	491	478	444
Average Sale Price	($)	130,605	130,045	134,815	127,720	123,097	126,367
Average No. Units Per Blk		2.6	2.5	2.5	2.3	2.5	2.5
Average Sale Price per Unit	($)	51,177	51,971	53,759	54,483	48,508	50,822

Price Index Base: Half Year Ended December 1989 = 1000

Note: (1) The total number of sales and total sale price includes a number of miscellaneous sales that are not covered by the above categories.

(2) Care should be exercised in comparing average sale prices on this and other tables as distortions can arise through variations in the quality of properties sold.

(3) Due to rounding, figures may not always add to stated totals.

TABLE 8

HOUSES

Average Sale Price by Age Category - (Freehold Open Market)
Half Year Ended June 1991

Local Authority		R8	R1	R2	R3	R4	R5	R6	R7	R8	R9
FAR NORTH		63394	78400	71700	69571	64483	75146	74800	101155	120386	-
WHANGAREI		94280	116824	87316	95464	81187	84597	94747	107759	129358	124889
KAIPARA		60175	50606	79000	96667	49500	69250	78409	99105	105875	-
RODNEY		98680	104626	87000	79000	130035	124108	145364	156701	160188	138950
#NORTH SHORE CITY	(A)	93222	222292	217222	250021	168386	171688	154241	176459	197892	168373
#WAITAKERE CITY	(A)	92188	116150	108717	121325	110154	113403	112176	125260	128714	133116
#AUCKLAND CITY	(A)	68021	185627	174325	181590	172143	164140	178120	225074	227463	174331
#MANUKAU CITY	(A)	97786	187667	123765	143222	127690	129421	125110	151251	195570	119059
#PAPAKURA	(A)	89750	96000	118143	97500	108400	121154	110235	134793	177357	223000
FRANKLIN		82350	111750	99214	101250	78667	96804	104950	138667	132019	-

TRAFFIC EFFECTS
SURVEY QUESTIONNAIRE

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Please read questions clearly and precisely.
Be courteous and helpful to respondents.
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Good morning/afternoon. My name is .... , and I would like to question the head of the household about house valuation. I am conducting a survey commissioned by Transit New Zealand to assess the value of effects of traffic in the urban environment.

I am going to ask you some questions about your valuation of the qualities of the urban environment. These questions relate to imaginary situations. The results of this survey will help establish the value of environmental effects of road traffic.

QUESTION 1

Imagine that you have decided to buy a new house. You have looked at a lot of houses on the market and you have found three possibilities that suit you. The houses are exactly the same in all respects, are set back from the street by a typical distance (about 12 metres), and have low fences on the street frontage.

Each of the houses are located on different streets. The of amount of traffic in the street and the width of the street are the only variables (Show cards).

[A]■ **VERY BUSY STREET**

This street is a major traffic route and carries a heavy traffic load during the day. At night the traffic flow reduces, but is more or less continuous. The street is about 23 metres wide, kerb to kerb. Parking on the kerbside is possible, but care and patience is required to negotiate the traffic. Turning into and out of driveways can be difficult during peak hours. During the day there is also a fair amount of cycle and pedestrian traffic.

[B]■ **AVERAGE STREET**

This street is a relatively busy traffic route and carries a moderate traffic flow. At night the flow reduces to occasional vehicles. The street is about 17 metres wide, kerb to kerb. Although some difficulty is encountered during peak hours, entry into and out of the driveway is not hindered by passing traffic. Occasional pedestrian and cycle traffic.

[C]■ **VERY QUIET STREET**

This street is no exit and is very quiet. It only has traffic going to and from local houses. During night time there is very little traffic. Pedestrian and cycle traffic is rare.

Now....

If you had a choice between the house on the very busy street [A] and the one on the averagely busy street [B], how much extra would you be prepared to pay for the house on the less busy street? (Show card A).

If you had a choice between the averagely busy street [B] and the very quiet street [C], how much extra would you be prepared to pay for the house on the very quiet street? (Show card A).

QUESTION 2

Now I would like you to imagine another situation. You have the choice of two identical houses both situated on a moderately busy street. The only difference between the houses is that the first house has a low front fence and a few shrubs between the house and the road. The second house has a solid six foot high timber fence (with gateways) and trees and shrubs screening the house from the road, with the combined effect of reducing noise from the street and view of the street significantly.

Can you indicate from the card the extra amount you would be prepared to pay for the house with the screening, compared to the house open to the street? (Show card A).

QUESTION 3

Now I would like to ask you to imagine choosing between three houses on a moderately busy street. They are all identical except that one house is situated on a corner section, one house has a typical set-back (say about 12 metres) with a low fence and a few shrubs. The third house is on a back section well away from the street.

If you had to choose between the corner-section house and the house with a typical section, how much extra would you pay to have the house on typical section rather than the corner-section house? (Show card A).

If you had to choose between the house on a typical section and the house on a back section, how much extra would you be prepared to pay to have the house on back section rather than the typical section house? (Show card A).

QUESTION 4

I would now like to ask you about the household. To which age group do you belong?

[ ] Older than 60
[ ] 45 to 60
[ ] 30 to 45
[ ] Younger than 30

Number of Adults?

[ ]

Number of Children?

[ ] Pre-School

[ ] Primary School

[ ] Secondary School

What is the approximate annual household income group?

[ ] Less than $20,000

[ ] $20,000 to $30,000

[ ] $30,000 to $45,000

[ ] $45,000 to $65,000

[ ] More than $65,000

QUESTION 5

Can you tell me what things about the traffic in your street and the layout of your street, you dislike?

....

....

Do you consider that you are affected (Yes or No) by the following attributes of your street? (Show Card B and read out items).

Did traffic effects play any part in your last house purchase decision?

☐ YES

☐ NO

Is there anything you found out about the house, its situation, or the road traffic since you moved in here?

....

....

THANK YOU FOR YOUR PARTICIPATION

CARD A: Dollar Values

- ☐ more than $50,000
- ☐ $50,000
- ☐ $40,000
- ☐ $30,000
- ☐ $25,000
- ☐ $20,000
- ☐ $15,000
- ☐ $12,500
- ☐ $10,000
- ☐ $7,500
- ☐ $5,000
- ☐ $2,500
- ☐ zero

CARD B: Traffic & Street Attributes

- ☐ General Daytime Traffic Noise
- ☐ Noise from Vehicles late at Night
- ☐ Heavy Vehicles Using the Road
- ☐ Traffic Fumes
- ☐ Sight of Traffic in the Street
- ☐ People Looking into the Property from the Street
- ☐ Glare from Headlights at Night
- ☐ Not Enough Street lighting at Night
- ☐ Safety of Children Wandering into the Street
- ☐ Safety of Children Cycling on Streets/Footpaths
- ☐ Safety for Adults Crossing the Street
- ☐ Cars Parked Along the Kerb
- ☐ Traffic Signs and Road Markings
- ☐ Power and Telephone Lines
- ☐ Streets Too Wide
- ☐ Streets Too Narrow

Do any of the above items have a <u>positive</u> impact?

....

....