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SUPPLEMENTAL TECHNICAL REPORT NUMBER 2

THE IMPACT OF AIRCRAFT NOISE ON RESIDENTIAL PROPERTY VALUES IN THE BOB HOPE AIRPORT ENVIRONS

Prepared for

Burbank-Glendale-Pasadena Airport Authority
Burbank, California

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BURBANK-GLENDALE-PASADENA AIRPORT AUTHORITY
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THE IMPACT OF AIRCRAFT NOISE ON RESIDENTIAL PROPERTY VALUES IN THE BOB HOPE AIRPORT ENVIRONS

1.0 SUMMARY OF FINDINGS

A hedonic model of the Bob Hope Airport area housing market was developed to investigate the impact of aircraft noise on the price of housing. A model was developed that showed a distinct relationship between CNEL noise levels and housing prices. Noise discount indices (NDIs) were computed from the results of the study. The NDIs describe the rate at which housing prices increase as noise decreases and reveal that the imposition of a curfew would result in an increase in property values within the Airport's 65 CNEL contour.*

2.0 PURPOSE OF STUDY

Federal Aviation Regulation (FAR) Part 161 requires the preparation of a detailed benefit-cost analysis to assess the impacts of a proposed airport noise restriction.** Research conducted in North America, the United Kingdom, and Australia over the past 30 years has found that airport noise adversely affects residential property values. If airport noise has affected residential property values in the Bob Hope Airport area, then an airport operating restriction which reduces airport noise could potentially result in an increase in housing values. This effect, therefore, should be identified in the benefit-cost analysis as a benefit of the proposed restriction.

This report describes a hedonic modeling study*** that was undertaken to determine whether aircraft noise at Bob Hope Airport influences housing prices in areas exposed to noise above 65 CNEL and, if so, to establish a quantitative relationship between the magnitude of aircraft noise and the price of housing. The study found convincing evidence that aircraft noise in the Airport vicinity does indeed influence residential property values.

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*The impact of noise on property values reflects an impact that must have been capitalized into property values long ago, since CNEL levels at the airport have been reducing steadily over the past 25 years or more.

**14 CFR part 161, Section 161.305 (e)(2)(ii)(1).

***Hedonic modeling is a method of estimating the marginal price of environmental amenities or nuisances that are bundled into a larger product that is exchanged through markets. Much of the research by economists into the influence of environmental amenities and impacts on housing prices has relied upon hedonic models. Hedonic modeling has become an accepted and well-developed method for investigating these issues (Harris 1981). According to the Merriam Webster on-line dictionary, "hedonic" means "of relating to, or characterized by pleasure." This term was probably selected to describe these models because they were originally developed to estimate the implicit price people are willing to pay for the pleasure derived from various environmental qualities at their home sites.

The results of this study are used to develop an estimate of the potential increase in the value of residential property inside the 65 CNEL contour that may result from the reduction of Airport noise with implementation of the three curfew alternatives analyzed in the Part 161 Study.* That analysis is documented in Appendix D of the FAR Part 161 Application, where the estimated impact of aircraft noise on housing prices with and without the alternative curfews is presented. The difference in impact between the baseline case and the proposed curfew would be the benefit attributable to the curfew. Any increase in property value would be a one-time event that would be capitalized into the value of the property shortly after implementation of the restriction.

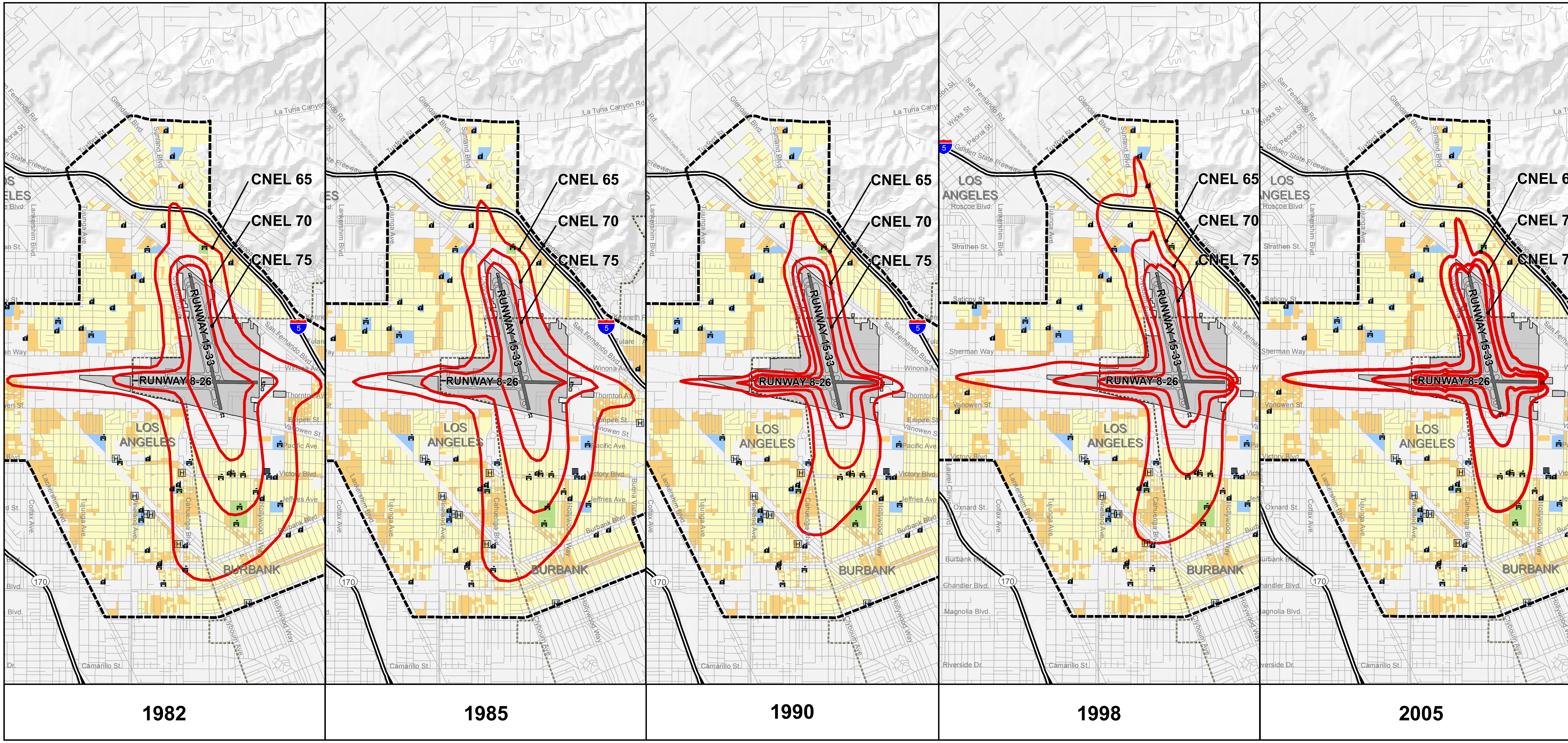
3.0 AIRPORT NOISE IN THE BOB HOPE AIRPORT AREA

Airport noise has been an issue in the Bob Hope Airport environs since the 1970s. Since the Burbank-Glendale-Pasadena Airport Authority acquired the Airport in 1978, it has adopted noise regulations, established noise abatement policies, and undertaken three noise compatibility studies in an effort to reduce noise exposure in the community.

Figure 1 shows the changes in the Airport's noise contours between 1982 and 2005. The area within the contours has steadily declined through the period. If airport noise has had an adverse impact on residential property values, and if that effect is related directly to the magnitude of CNEL noise levels, the adverse effect should have been declining over time as the noise exposure has lessened.

Nevertheless, some local residents continue to believe that airport noise is detrimental to residential property values. Those concerns were stated at several listening sessions held for the FAR Part 161 Study in the summer of 2000.

*Three curfew alternatives are analyzed in the FAR Part 161 Study: a full curfew on all nighttime operations (from 10:00 p.m. to 6:59 a.m.); a curfew on nighttime departures; and a noise-based curfew prohibiting nighttime operations by aircraft with cumulative FAR Part 36 noise levels above 253 EPNdB.



LEGEND

- CNEL Contour
- Detailed Land Use Study Area
- Airport Boundary
- Municipal Boundary
- Freeways
- Roads
- Single-Family Residential
- Multi-Family Residential
- Noise-Sensitive Institutions
- Sound-Insulated School
- Schools, Preschools
- Places of Worship
- Hospital
- Library

NORTH

0 1,300 2,600 5,200 Feet

Sources:
1982 - CH2M HILL, Noise Abatement Plan, 1983
1985 - KMPG Peat Marwick, FAR Part 150 Noise Compatibility Program, Vol. 1: Noise Exposure Maps, 1987.
1990 - KMPG Peat Marwick, Final EIS, Land Acquisition and Replacement Terminal Project, Vol. 1: Documentation, 1995.
1998 - Coffman Associates, Burbank-Glendale-Pasadena Airport FAR Part 150 Noise Compatibility Study, Noise Exposure Maps.
2005 - Jacobs Consultancy, 2007

Figure 1
HISTORICAL CHANGES IN NOISE EXPOSURE AT BOB HOPE AIRPORT
FAR Part 161 Study for Bob Hope Airport
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4.0 PRIOR RESEARCH

Since the 1970s, many studies have investigated the impact of airport noise on residential property values. Studies at 27 airports in North America, the United Kingdom, and Australia are summarized in Table 1. In all but two studies (the London and the Winnipeg studies), noise was described using cumulative noise descriptors generally similar to DNL and CNEL. All of the studies found some degree of impact on residential property values due to aircraft noise. The last column of the table presents a “Noise Depreciation Index” or “Noise Discount Index” (NDI) describing the percentage reduction in property value attributable to a one-decibel increase in noise above the impact threshold. Most of the studies concluded that changes in price are related in a linear fashion to changes in noise levels. The NDI ranges from a low of 0.29 percent to a high of 1.36 percent. A simple average, computed from the NDI values reported in the table, is 0.67 percent. The median NDI for all studies is 0.62 percent.

Most of the studies considered the effects of airport noise on the price of conventional single-family housing. Two of the studies considered the impacts on apartments and rental units, and one considered condominiums. Although the research experience is limited, the degree of impact on multiple-unit housing types is similar to the impacts found on single-family housing. In fact, these three studies found NDIs somewhat higher (between .80 and .90) than the overall average indicated in Table 1.

A meta-analysis of over 30 hedonic modeling studies published in 2004 produced findings similar to those shown in Table 1 (Nelson 2004). That analysis considered only studies done in the United States and Canada. While it included all of the North American studies shown in Table 1, it also included the results of five other unpublished studies. The meta-analysis found a mean NDI of 0.75% and a median NDI of 0.67% .

While these studies have revealed the potential for noise effects on property values and have demonstrated effective methods for exploring the issue, the results cannot be applied directly to the Bob Hope Airport vicinity. One reason is that the housing markets around these other airports are likely to be much different than the Bob Hope Airport area. Further, the prior studies were undertaken as pure research with the intent to understand the potential effects of aircraft noise on property values. No specific follow-up, policy-related actions were contemplated. Thus, certain aspects of the designs of those studies would limit their applicability to the situation at Bob Hope Airport.

Table 1

FINDINGS OF PREVIOUS STUDIES OF THE IMPACT OF AIRPORT NOISE ON RESIDENTIAL PROPERTY VALUES

Study Area	Citation	Noise Descriptor[1]	Threshold of Impact[2]	NDI (%)[3]
Addison, TX	Nicosia 2003	DNL	55 DNL	.80 (apartments)
Atlanta, GA	O'Byrne et al. 1985	DNL	65 DNL	0.52 to 0.70
Baltimore, MD	Booz Allen & Hamilton, Inc. 1994	DNL	72 DNL	0.04 to 1.05[4]
Boston, MA	Price 1974[5]	NEF	NEF 25 (60 DNL)	0.83 (rental units)
Buffalo, NY	Nelson 1978a, 1979, 1980, 1981	NEF	NEF 25 (60 DNL)	0.52
Cleveland, OH	Nelson 1978a, 1979, 1980, 1981	NEF	NEF 25 (60 DNL)	0.29
Dallas-Love Field, TX	De Vany 1976[5]	NEF	NEF 20 (55 DNL)	0.58
Edmonton, AB	McMillan et al. 1978[5]	NEF	NEF 20 (55 DNL)	0.50
London Heathrow - Cranford, UK	Gautrin 1975	NNI	55 NNI (74 DNL)	0.56 to 0.68[5]
Los Angeles, CA	Booz Allen & Hamilton, Inc. 1994	CNEL	69 to 72 CNEL	0.07 to 1.36[4]
Manchester –Stockport, UK	Tomkins et al. 1998	Leq	57 Leq	0.78[6]
Minneapolis, MN	Emerson 1969, 1972[5]	CNR	CNR 100 (63 DNL)	0.58
New Orleans, LA	Nelson 1978a, 1979, 1980, 1981	NEF	25 NEF (60 DNL)	0.40
New York, NY (JFK)	Booz Allen & Hamilton, Inc. 1994	DNL	67 DNL	0.12 to 1.35[4]
New York, NY (LGA)	Booz Allen & Hamilton, Inc. 1994	DNL	67 DNL	0.46 to 0.64[4]
Reno, NV	Espey and Lopez 2000	DNL	65 DNL	0.43
Rochester, NY (urban area)	Maser et al. 1977[5]	PNdB	100 PNdB	0.82 to 0.95
Rochester, NY (suburban area)	Maser et al. 1977[5]	PNdB	100 PNdB	0.55 to 0.68
St. Louis MO	Nelson 1978a, 1979, 1980, 1981	NEF	25 NEF (60 DNL)	0.51
San Diego, CA	Nelson 1978a, 1979, 1980, 1981	NEF	25 NEF (60 DNL)	0.74
San Francisco, CA	Dygert 1973[5]	NEF	25 NEF (60 DNL)	0.50
San Francisco, CA	Nelson 1978a, 1979, 1980, 1981	NEF	25 NEF (60 DNL)	0.58
San Jose, CA	Dygert 1973[5]	NEF	25 NEF (60 DNL)	0.70
Sydney—Marrickville, AUS	Abelson 1979[5]	NEF	25 NEF (60 DNL)	0.40

Table 1 *(continued)*

FINDINGS OF PREVIOUS STATISTICAL STUDIES OF THE IMPACT OF AIRPORT NOISE ON RESIDENTIAL PROPERTY VALUES

Study Area	Citation	Noise Descriptor[1]	Threshold of Impact[2]	NDI (%)[3]
Sydney—Rockdale, AUS	Abelson l979[5]	NEF	NEF 25 (60 DNL)	0.50
Toronto--Etobicoke, ON	Mieszkowski and Saper 1978	CNR, NEF	CNR 95 (58 DNL) NEF 25 (60 DNL)	0.95[7]
Toronto--Mississauga, ON	Mieszkowski and Saper 1978	CNR, NEF	CNR 95 (58 DNL) NEF 25 (60 DNL)	0.87[7]
Vancouver, BC	Uyeno et al. 1993	NEF	NEF 25 (60 DNL)	0.65 (single-family housing) .90 (condominiums)
Washington, DC	Nelson 1978b	NEF	NEF 20 (55 DNL)	1. 06[7]
Winnipeg, MB	Levesque 1994	Mean EPNL for events over 75 EPNL	Mean EPNL of 75 dB	Curvilinear (about 1.3% between 78 to 92 EPNL)
Average NDI				***0.67***[3]
Median NDI				***0.62***[3]

[1] Most of these descriptors are measures of cumulative noise exposure over an average 24-hour period. Definitions of descriptors:
CNEL – community noise equivalent level, a cumulative metric computed by integrating the total sound energy over 24 hours, with a 5-decibel weight added to sounds between 7:00 p.m. and 10:00 p.m. and a 10-decibel weight added to sounds after 10:00 p.m. and before 7:00 a.m. (used in California per State law).
CNR – composite noise rating, a cumulative metric based on the maximum perceived noise level (PNdB) and the number of flights during the day and night.
DNL – yearly day-night average noise level, a cumulative metric computed by integrating the total sound energy over 24 hours, with a 10-decibel weight added to sounds after 10:00 p.m. and before 7:00 a.m.
EPNL – effective perceived noise level, a single-event metric computed by integrating the instantaneous sound level of a single event, described by the PNdB metric, over a standard time period (e.g., one second).
Leq -- equivalent sound level, a cumulative metric computed by integrating the total sound energy over a given period of time, 24 hours in the case of these studies.
NEF – noise exposure forecast, a 24-hour cumulative noise metric developed from the EPNL single-event metric.
NNI – noise and number index, a cumulative metric which accounts for the average peak sound level (PNdB) and the number of flights over the 24-hour period.
PNdB – perceived noise level, an instantaneous sound metric developed from sound levels measured in octave or one-third octave bands.

[2] DNL equivalents computed by Jacobs Consultancy based on the following formulas: DNL = NEF+35; DNL = CNR–37; DNL = NNI+19 (FAA 1985, Truax 1999). CNEL values tend to be nearly the same as DNL values. Leq, Mean EPNL, and PNdB cannot be directly converted to DNL equivalents.

[3] NDI -- Noise Depreciation (or Discount) Index. The value represents the percentage decrease in property value attributable to a one-decibel increase in noise above the impact threshold.

[4] NDIs for Baltimore, Los Angeles and New York were developed using both appraisal and hedonic modeling methods. (The low NDIs reported in the table were all developed through the appraisal methods.) In Los Angeles and New York, the NDIs were found to increase as average home values in the study neighborhoods increased. It was not possible to derive an overall average NDI from these studies, so they were excluded in the computation of the average and median NDIs in this table.

[5] Study summarized in Nelson l980. Nelson computed the NDI values reported in this table.

[6] Proximity to employment centers (the London CBD and Heathrow or Manchester Airport) were positively correlated with housing price and tended to offset the negative impacts of airport noise on housing values. The NDI reported in the table is the negative impact of airport noise, all other things being equal.

[7] Computed by and reported in Nelson 2004.

For the Part 161 Study at Bob Hope Airport, it is necessary to estimate the potential for changes in the noise-related effect on property values based on alternative airport noise restrictions producing different levels of noise reduction. Hedonic modeling studies done at other airports produce results that are too coarse for this purpose. For example, the studies often describe aircraft noise as a simple "yes or no" variable, with areas inside a critical noise contour being labeled as "noisy" and those outside the area being labeled as "not noisy" (Mieszkowski and Saper 1978; Tomkins, et al. 1998; Espey and Lopez 2000). In other studies, noise is described by ranges, with all houses in a given area being assigned the same noise level (Nelson 1979; O'Byrne, et al. 1985; Pennington, et al. 1990; Tomkins, et al. 1998).

5.0 THE MEANING OF "NDI"

NDI, the noise depreciation or discount index, is the standard term of art in describing the quantitative relationship between noise and property values. The precise meaning of the NDI, however, depends on the particular circumstances of the airport and the local housing market under study.

Consider, at one extreme, a neighborhood affected by noise from a new airport. In such a circumstance, the large increase in noise levels caused by the new airport may lessen the value of housing, compared to pre-airport values, or lessen the rate of appreciation in values relative to similar neighborhoods that are not affected by the increase in noise. In that case, noise has caused a "depreciation" in property values.

Consider another situation where a neighborhood is developed after an airport has been in operation. If the property market is functioning properly, any impact of airport noise should have been capitalized into the value of the land and homes from the start of the development process. The airport noise cannot be claimed to have "harmed" residential property owners, per se. The price buyers paid for the new homes and lots should have reflected the lower capital valuation in the form of a "discounted" property value, relative to similar types of housing outside the noise impact area.

Bob Hope Airport was opened in 1930 and has been operating ever since. Until 1946, it was the primary commercial airport serving metropolitan Los Angeles. It was home to Lockheed's aircraft manufacturing plant and Advanced Development Programs (the Skunk Works) from the early 1940s to 1989. It has been an important secondary air carrier airport for the Los Angeles Region at least since the late 1960s when commercial jet service was introduced at the Airport.

The neighborhoods in the Airport area were developed primarily in the 1930s through the 1950s. (The median year of construction for the homes in the hedonic modeling study sample is 1943 and the average year of construction is 1945.) As the area developed, airport noise became an important local issue. It remains a concern of many local residents, even though the magnitude of noise, as measured by CNEL noise contours, has steadily declined at least over the last 25 years. (See Figure 1 on page 3 for a comparison of noise contours from 1982 to 2005.)

Bob Hope Airport and the surrounding neighborhoods have grown up together. Given the intense level of activity at the Airport over the years, any adverse noise-related effects on property were capitalized into the value of land long ago, perhaps all the way back to the original development of the neighborhoods. Thus, the NDIs computed in this hedonic modeling study, while offering evidence of a difference in property values in noise-impacted areas relative to low-noise areas, are not evidence of a "loss" in property value sustained in any neighborhood.

Any reduction in airport-vicinity noise over time, however, whether occurring as a normal outcome of industry trends or through deliberate Airport Authority policy (in the form of a curfew, for example) could result in an increase in property values, as predicted by the NDIs computed in this study.

6.0 RESEARCH METHODOLOGY AND DATA

6.1 Basic Principle of the Hedonic Model

The hedonic model is based on the theory that, when a market is in equilibrium, the price of housing can be predicted by the market valuation of a package of attributes (or services) afforded by a house. These include the location, the characteristics and features of the house, the character of the neighborhood (including local taxes and the quality and availability of public services), and various environmental amenities (or nuisances). A properly specified model can isolate the estimated effect of any of these attributes on the sale price of a house.

According to the hedonic model, the general housing price function is assumed to be:

$P = f(h, n, e)$, where:

P = housing sale price;
h = various housing characteristics;
n = various neighborhood characteristics;
e = various environmental characteristics,

6.2 A Housing Price Model for the Bob Hope Airport Area

A model of housing prices in the Airport area was developed based on a review of previous studies and a consideration of the available data in the local area. In addition, a focus group of seven local real estate professionals was convened on April 4, 2003 to discuss the nature of the local housing market. Their observations were used in specifying the final model.

The general functional form of the model is represented as:

$$\ln(P) = \beta_0 + \beta_1 \ln(X) + \beta_2 Y + \beta_3 Z + \beta_4 \text{NOISE} + \varepsilon$$

where P is the sale price, X is a set of variables describing the size of the lot and living area, Y is a set of variables describing other characteristics of the house, and Z is the set of variables describing the neighborhood. NOISE represents the aircraft noise level at the house. The β's are the estimated regression coefficients, and ε is the stochastic error term. The natural logarithm (ln) of housing price is shown as the dependent variable so that the coefficient of the NOISE variable can be directly read as the percentage impact on the housing price per unit change in NOISE. (Nelson 2004).

6.2.1 Interpretation of the Noise Coefficient from the Hedonic Model

In economics terminology, the noise coefficient in a hedonic model represents the "marginal willingness to pay" to avoid (or abate) the noise. This is a valid interpretation of hedonic modeling coefficients for any environmental attribute that is a localized externality. Strictly speaking, the results of a hedonic model indicate an equilibrium price schedule rather than a demand curve for any attribute in the model. Nevertheless, formal estimation of a demand curve for the attribute of interest is unnecessary if the objective is to estimate the benefits of abating (or promoting) the given attribute.*

The notion of a localized externality was first clearly articulated by Palmquist (1992a, 1992b). According to Palmquist (1992b, p. 40):

> A localized externality affects only a limited number of houses in a neighborhood [because such effects] . . . diminish very rapidly with distance . . . It is fortunate that benefit estimation for localized externality abatement does not require estimation of the second stage of the hedonic model.

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*Estimation of a demand function requires a two-stage approach, beginning with hedonic modeling, which assumes a general equilibrium case where the hedonic prices are endogenous. The second-stage estimation treats these prices as jointly determined by demand and supply for the housing attribute in question. Estimation of demand functions for housing attributes remains a controversial topic in applied econometrics; see Coulson (2008) and Sheppard (1999) for discussion of methods and procedures for second-stage identification.

This interpretation of the hedonic model coefficients has been widely adopted and used to justify application of such coefficients for policy analysis, such as full cost pricing of transportation modes and benefit-cost analysis of transportation projects (see Nelson 2008 for numerous examples). For example, the widely-cited book by A. Myrick Freeman (1993, p. 397) summarizes the conceptual problem as follows:*

> If the hedonic price function does not shift, then exact welfare measurement may be a relatively easy task. One situation in which the hedonic price function could be assumed to be constant is when the number of sites at which there is a change in amenity level is *small relative to the total urban market*. If this is the case, and if individuals can move without cost from one site to another in response to the change in environmental amenity levels, then exact welfare measurement is straightforward. The hedonic price function can be used to predict the changes in the prices of affected properties. Benefits are exactly measured by the increase in the values of affected properties. And knowledge of the marginal bid [i.e., inverse demand] function is not required (emphasis added).**

6.2.2 Aircraft Noise as a Localized Externality

Palmquist (1992a, 1992b) provides numerous examples of localized externalities, including hazardous waste sites, landfills, highway noise, leaks from underground storage tanks, and housing code violations. The important feature of these examples is that the adverse effects of the externality diminish rapidly with distance, so the number of affected properties is small relative to the total housing market (Palmquist 2005, p. 774).

In the Bob Hope Airport environs, aircraft noise certainly fits the definition of a localized externality. Consider first the number of dwellings exposed to aircraft noise from Bob Hope Airport. Based on 1998 noise exposure, 2,184 dwellings were inside the 65 CNEL contour.*** This can be taken as a conservative estimate of the number of homes exposed to aircraft noise. Given the pattern of noise complaints shown in Figure 2, however, it is likely that aircraft noise at levels below 65 CNEL is a concern of enough people to have some effect on the bid prices for housing. As an

*Among the other authors who adopt a similar position are Day (2001), Haab and McConnell (2002, p. 248), Palmquist (2005, p. 774), and Taylor (2003). A recent example of use of marginal hedonic prices for benefit-cost analysis of aircraft noise is found in Waitz et al. (2008).

**Note that the author is speaking in theoretical terms. When policy analysts apply the results of hedonic modeling in actual settings, they must recognize that individuals cannot "move without cost from one site to another in response to the change in environmental amenity levels" and that, accordingly, "exact welfare measurement" using hedonic modeling results is not possible. In actual field settings, the results of hedonic modeling can, at best, be used as estimates of changes in welfare when key conditions for proper use of the model are met.

***Coffman Associates 1998. *Burbank-Glendale-Pasadena Airport F.A.R. Part 150 Noise Compatibility Study Update, Noise Exposure Maps*, p. 4-6.

estimate of the maximum number of homes within the area of noise effect, the number of homes inside the 65 CNEL contour is multiplied by a factor of 10.*

Two alternative descriptions of the relevant housing market, within which the "noise-affected" housing units are located, are considered.** The smaller is the San Fernando Valley, the larger is Los Angeles County. Based on the 2000 Census, the San Fernando Valley had 585,000 households.*** Los Angeles County had 3.13 million households.

Using these data, area exposed to aircraft noise in the Bob Hope Airport environs accounts for 0.4% to 3.7% of the housing within the San Fernando Valley, and .07% to 0.7% in Los Angeles County. Although exact quantification is uncertain, we can safely conclude that for purposes of a benefit-cost analysis, the local externality condition does apply for the Bob Hope Airport, and hence benefit-cost analysis can be based on the hedonic model coefficients.

6.3 Study Area

The study area was based on the area from which most aircraft noise complaints have historically been filed. This includes all areas within the 65 CNEL contour for the 1998 Noise Exposure Map and beyond (from 2.0 to 5.5 statute miles from each runway end). The shape of the study area reflects the shape of the 65 CNEL contour and includes heavily used flight corridors. Much of the study area is actually exposed to noise levels below 65 CNEL. This was done to allow the predictive equations to be tested for a wide range of noise levels, in the attempt to derive a dose-response relationship correlating housing price with aircraft noise over a range of levels. Figure 2 shows the study area, including noise complaint locations.

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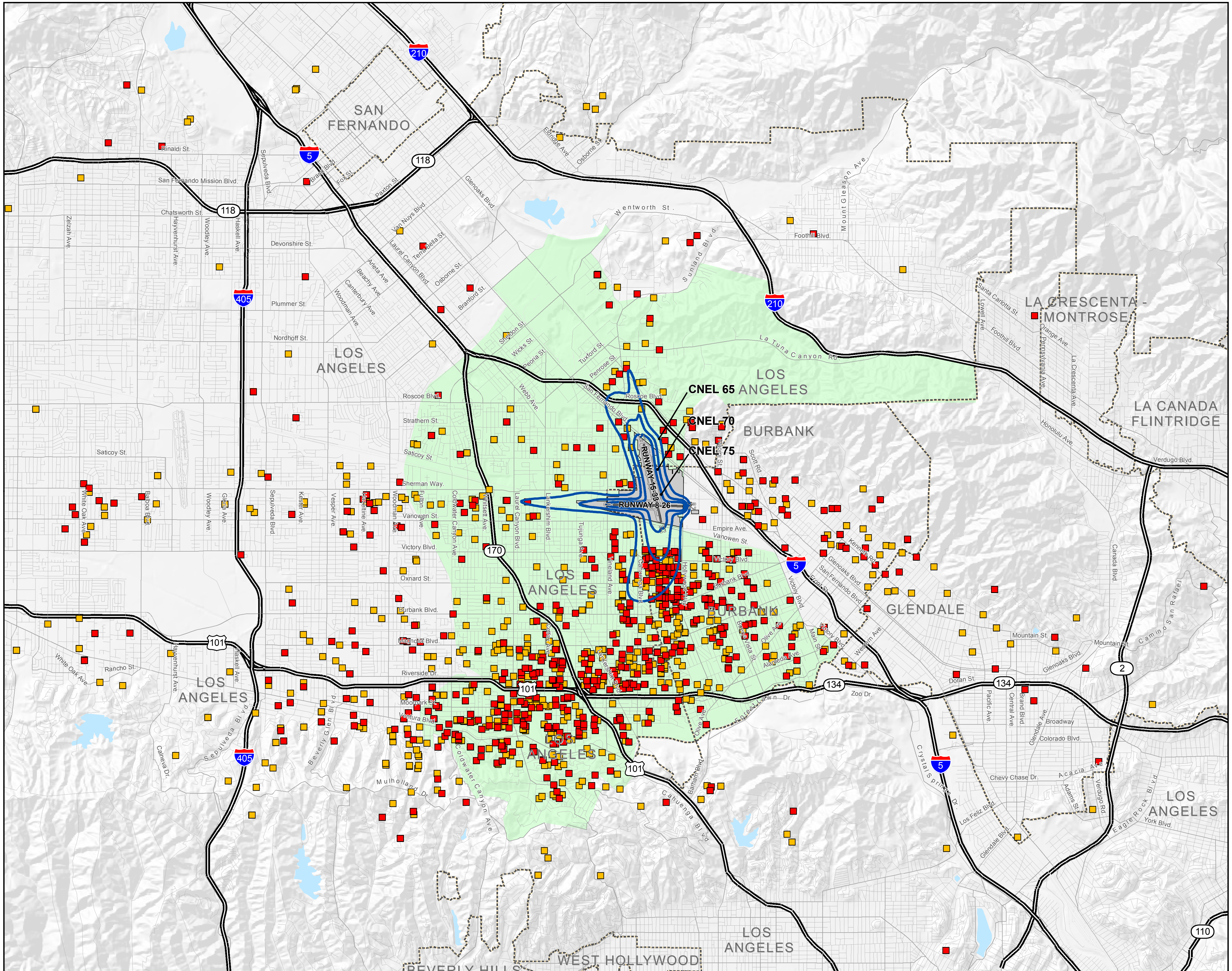
*The area within noise contours increases geometrically as the contours decrease in noise level. This factor was chosen in recognition of that phenomenon.

**As noted by Palmquist (2005, p. 784), most researchers today take an urban area to be a single housing market. This does not preclude the existence of "submarkets" for analysis, i.e., it is likely that the Los Angeles Metropolitan Area, which has 12.9 million residents, contains several identifiable markets.

***The San Fernando Valley is not a census-designated place, so estimates of demographic data for the area vary, depending on how the analyst sets the boundaries of the area. These estimates are taken from the following website: http://www.csun.edu/sfverc/Data/2000demographic.html.



Source: Noise complaint data for 1996-2000 from Burbank-Glendale-Pasadena Airport Authority Noise Office.

Figure 2
STUDY AREA FOR HEDONIC MODELING OF PROPERTY VALUES
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6.4 Study Sample

Parcel records from the Los Angeles County Assessor were secured for the following zip codes:

- 91352 -- Sun Valley/La Tuna Canyon
- 91505 -- Burbank
- 91506 -- Burbank
- 91601 -- North Hollywood
- 91602 -- North Hollywood/Studio City
- 91604 -- Studio City/Sherman Oaks
- 91605 -- Sun Valley
- 91606 -- North Hollywood
- 91607 -- Studio City/Valley Village

The County Assessor's records include the date and price of the last three sales for each property. Cases selected for the study included all single-family dwellings where the most recent sales date was in either 1998 or 1999. Cases for which key variables (such as sale prices or the number of bedrooms or bathrooms) were missing were dropped from the sample. Other cases where the sale values were in apparent error or where they may have been reflecting non-market rate transfers between friends or family members also were eliminated. A total of 3,462 cases were in the final study sample.

6.5 Selected Variables and Sources of Data

6.5.1 Housing Characteristics

Housing characteristics selected for the analysis are listed in Table 2. All may be reasonably assumed to have some impact on housing value, although the list does not include all variables that may conceivably be important. (Characteristics excluded from this study that have been used in other studies include the total number of rooms, the presence of a recreation room or family room, the presence of a garage, the presence of a basement, and whether or not it is finished, and the presence of fireplaces.) The housing characteristics selected for this analysis were based on their availability from the Los Angeles County Assessor's office.

Table 2

HOUSING CHARACTERISTICS USED IN MODEL*

Bob Hope Airport FAR Part 161 Study

Variable	Description
L	Lot area in square feet (logged in the modeled equation)
SF	Square footage of house (logged in the modeled equation)
AGE	Age of the building in years
HP_N	Housing design type/pool -- a dummy variable where homes without a swimming pool (or therapy pool) are coded as 1; 0 otherwise.
HC_L	Housing condition class of "low" or "low-medium," coded as 1; 0 otherwise.
B*	Number of bathrooms -- a dummy variable, coded as 1 or 0 over the range of the number of bathrooms (B1 to B4 -- from 1 to 4 or more).
R*	Number of bedrooms -- a dummy variable, coded as 1 or 0 over the range of the number of bedrooms (R1 to R7 – from 1 to 7 or more).
T	Time when the home was sold – a dummy variable where each calendar quarter in 1998 and 1999 (T1 through T8) is coded as 1 or 0.

*While all variables were considered in the exploratory phases of the analysis, several were dropped from the final model because of limited explanatory power or because of multi-colinearity problems. Among the variables excluded from the final model were B1 and B2 (one and two bathrooms) and all R variables.

Dummy variables were used for the number of bedrooms and bathrooms because it is possible that the marginal valuation of each additional unit of these variables is not constant. In other words, it is quite possible that the additional value of a third bedroom is different than the additional value of a fourth or fifth bedroom.

A dummy variable was used for each calendar quarter in which houses were sold. This was to account for the effects of seasonal variation and inflation so that those effects would not bias the other regression coefficients.

6.5.2 Neighborhood Characteristics

The neighborhood characteristics selected for the analysis are listed in Table 3. The first characteristic, "municipality," represents the primary taxing jurisdictions in the study area – the municipalities and the school districts. The school district boundaries correspond to the municipal boundaries. Thus, only the municipality (M) in which each house is located – either Los Angeles or Burbank -- was used as a variable in the model.

Table 3

NEIGHBORHOOD CHARACTERISTICS USED IN MODEL*

Bob Hope Airport FAR Part 161 Study

Variable	Description
M*	Municipality – a dummy variable; coded as 1 or 0 for each municipality (M_{LA} - Los Angeles or Mb - Burbank) in the study area.
D_{ES}*	Distance in miles to nearest public elementary school – measured as line-of-sight distance.
Q_{ES}	Quality of the nearest public elementary school -- expressed as the mean of the percentage of students scoring above the 50th percentile on the 1998 Stanford 9 test, in all grades, in all subjects.
Q_{MS}	Quality of the nearest public middle school – expressed as the mean of the percentage of students scoring above the 50th percentile on the 1998 Stanford 9 test, in all grades, in all subjects.
Q_{HS}*	Quality of the nearest public high school -- expressed as the mean of the percentage of students scoring above the 50th percentile on the 1998 Stanford 9 test, in all grades, in all subjects.
ES*	A dummy variable noting the elementary school attendance area within which the home is located (ES1 to ES31).
MS*	A dummy variable noting the middle school attendance area (MS1 to MS9).
HS*	A dummy variable noting the high school attendance area (HS1 to HS6).
D_F	Distance in miles to the nearest freeway entrance or exit ramp -- measured as line-of-sight distance.
F	Adjacent or near to freeway right-of-way -- a dummy variable where the location of the property within 500 feet of the freeway centerline is coded as 1 (yes) or 0 (no).
ST	Frontage along "arterial street", as defined in the Burbank and North Hollywood comprehensive plans -- a dummy variable where addresses on arterial streets are coded as 1 and those not on arterial streets are coded as 0,
CR_P	Property crime rate -- a continuous variable computed by dividing the number of property crimes reported in 1998 for each police station area by the population of the area (derived from 2000 Census tract data). Property crimes are defined as burglary and attempted burglary, larceny, and vehicle theft.
CR_V*	Violent crime rate -- a continuous variable computed by dividing the number of violent crimes reported in 1998 for each police station area by the population of the area (derived from 2000 Census tract data). Violent crimes are defined as homicide, aggravated assault, rape and attempted rape, - robbery and attempted robbery.

*While all variables were considered in the exploratory phases of the analysis, several were dropped from the final model because of limited explanatory power or because of multi-co linearity problems. Among the variables excluded from the final model were M, D_{ES}, Q_{HS}, several of the school attendance areas, and CR_V.

Seven school variables were used in the regression model. These include distance to the nearest public elementary school (D_{ES}), the quality of the nearest public elementary school (Q_{ES}), the quality of the nearest public middle school (Q_{MS}), and the quality of the nearest public high school (Q_{HS}). School quality was described as the mean of the percentage of students scoring above the 10th percentile (in all subjects) in the 1998 Stanford 9 test. In addition, three sets of dummy variables were used to denote the elementary school, middle school, and high school attendance areas in which each home is located.

Another important consideration for prospective home buyers is distance to the workplace. There are multiple employment centers in the Los Angeles and San Fernando Valley areas. Thus, the distance to the nearest freeway entrance or exit ramp (D_F) was used as a proxy for the distance to work.

Several freeways pass through residential sections of the study area. The value of houses adjacent to or very near the freeway right-of-way may be adversely affected by the highway traffic noise and nighttime freeway lighting. Thus, proximity to the freeway (F) was also used as one of the neighborhood variables. "Proximity" was defined as being within 500 feet of the centerline of the freeway right-of-way.

Another important neighborhood variable is "frontage on an arterial street" (ST). Because most of the study area is a grid street pattern developed years ago, many houses front on arterial streets. It is likely that these houses have lower values than similar houses on quiet side streets.

Finally, crime rates by police station service area were included in the analysis.

6.6 Noise Variables

Five alternative descriptors of the aircraft noise variable were used in separate specifications of the hedonic model:

CNEL – Community noise equivalent level.

HA – A curvilinear transformation of the CNEL value using the revised Schultz Curve (Finegold et al. 1994).

HA_{FS} – A curvilinear transformation of the CNEL value using the Fidell-Silvati curve (Fidell and Silvati 2004).

HA_{MO} – A curvilinear transformation of the CNEL value using the Miedema-Oudshoorn curve (Miedema and Oudshoorn 2001).

LEQ_N – The Leq for nighttime noise – the nine-hour period between 10:00 p.m. and 7:00 a.m.

The three "HA" curves all describe the relationship between reported annoyance and cumulative noise exposure, typically expressed using the DNL (day-night average sound level) metric. While the revised Schultz Curve is based on annoyance attributable to noise from various transportation sources, the other two describe the relationship to noise from only aircraft sources. In the equations for each curve below, the CNEL metric is used for the "noise" term. The CNEL and DNL metrics are similar enough that they can be used interchangeably in these equations. In each equation, the term "HA" represents the percent of a population expected to be "highly annoyed" with aircraft noise.

Revised Schultz curve: $\%HA = \frac{100}{\left[1 + e^{(11.13-(0.141\times CNEL))}\right]}$

Fidell-Silvati curve: $\%HA_{FS} = \frac{100}{\left[1 + e^{(5.854-(0.075\times CNEL))}\right]}$

Miedema-Oudshoorn curve:

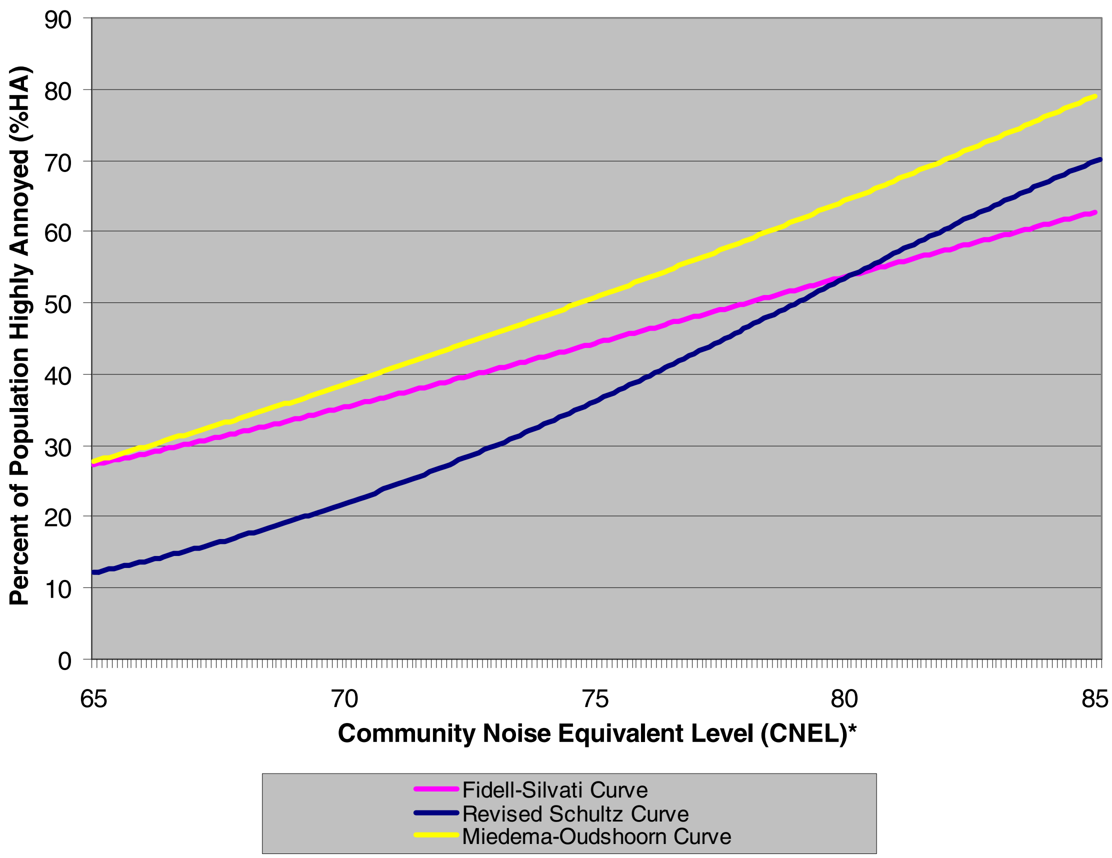
$$\%HA_{MO} = -1.395\times10^{-4}(CNEL-42)^3 + 4.081\times10^{-2}(CNEL-42)^2 + 0.342(CNEL-42)$$

Figure 3 shows the relationships between CNEL and the HA, HA_{FS} and HA_{MO} curves.

Figure 3

COMPARISON OF NOISE ANNOYANCE CURVES

Bob Hope Airport FAR Part 161 Study



Sources: Fidell and Silvati 2004; Finegold, et al., 1994; Miedema and Oudshoorn 2001.

All four descriptors – CNEL and the three HA metrics – are cumulative noise metrics, consistent with the types of noise variables used in most of the prior hedonic modeling research.

The nighttime Leq metric describes the cumulative noise level during the nine hours between 10:00 p.m. and 7:00 a.m. on an average night. The alternative curfews being considered in the Part 161 Study would restrict aircraft operations during these hours. This metric was selected to test whether nighttime noise was directly related residential property values.

6.6.1 Noise Above 65 CNEL

The Airport Authority's acoustical treatment program ameliorates adverse impacts of airport noise on residential property values in areas eligible for the program – corresponding to the area within the 65 CNEL contour. The acoustical treatment program began in 1997 with a pilot program for several homes. The program was fully started in 1998. The data set for the hedonic modeling study was drawn from sales in 1998 and 1999, before a large number of homes had been treated. The data set included no acoustically treated homes.

In an attempt to isolate the effects of noise on housing prices in areas exposed to noise above 65 CNEL, an additional set of noise variables was defined. Dummy variables were developed to represent "HIGH NOISE" – noise levels above 65 CNEL. The HIGH NOISE variables were defined as follows:

- HCNEL = HIGH-NOISE x CNEL, where HIGH-NOISE is a dummy variable equal to 1 at levels above 65 CNEL and 0 at lower levels.

- $HLEQ_N$ = HIGH-NOISE x LEQ_N, where HIGH-NOISE is a dummy variable equal to 1 at levels above 50 LEQ_N and 0 at lower levels.

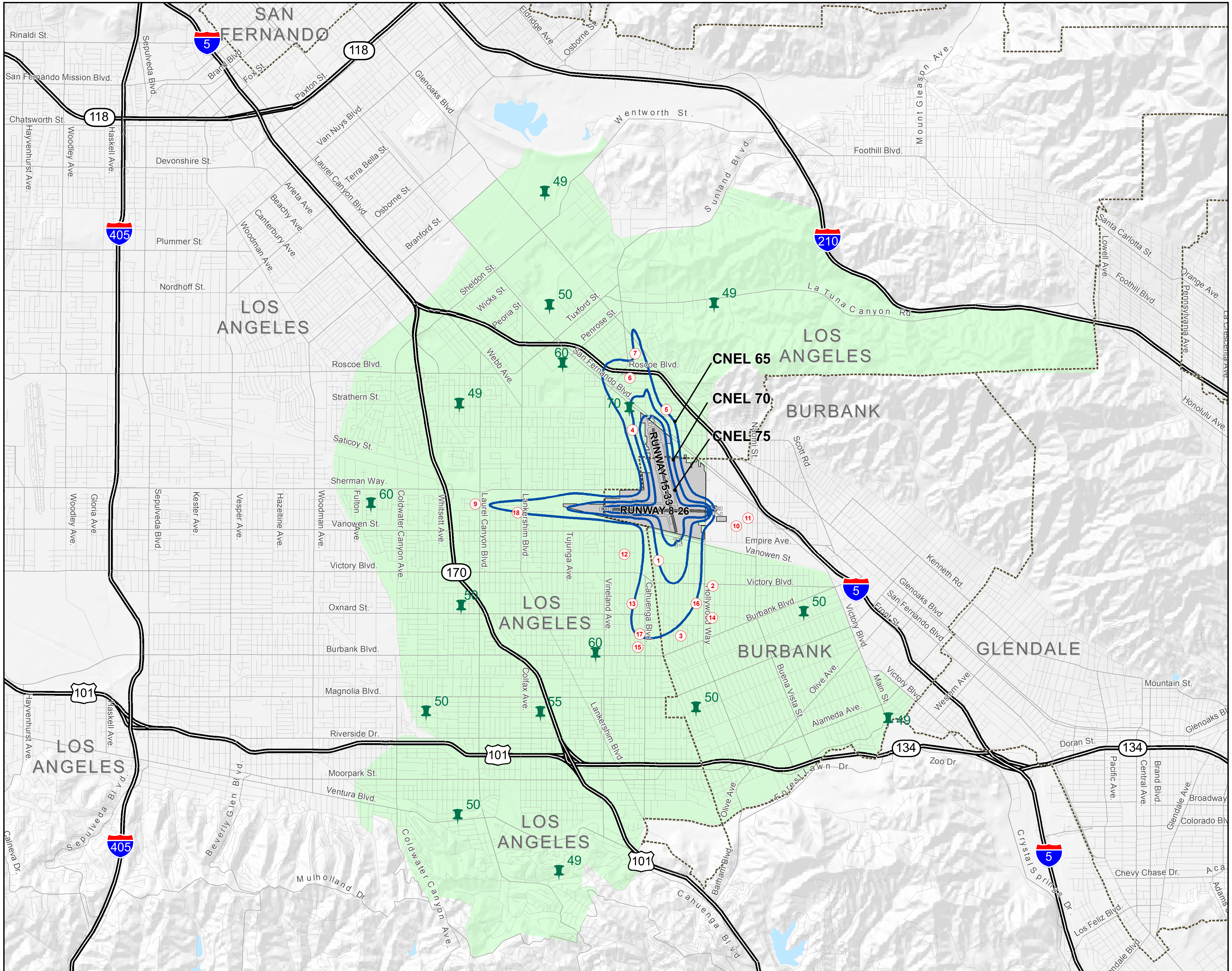
- HHA = HIGH-NOISE x HA, where HIGH-NOISE is a dummy variable equal to 1 at HA levels above 12.29 and 0 at lower levels. (The HA level at 65 CNEL is 12.29.)

- HHA_{FS} = HIGH-NOISE x HA_{FS}, where HIGH-NOISE is a dummy variable equal to 1 at HA_{FS} levels above 27.31 (equivalent to 65 CNEL) and 0 at lower levels.

- HHA_{MO} = HIGH-NOISE x HA_{MO}, where HIGH-NOISE is a dummy variable equal to 1 at HA_{MO} levels above 27.76 (equivalent to 65 CNEL) and 0 at lower levels.

6.6.2 Source of Noise Data

The values for the NOISE variables were computed for each address in the sample using the grid analysis feature of the Integrated Noise Model (INM), Version 6.1c. The INM file developed for the official 1998 Noise Exposure Map (NEM) was used because, at the time the hedonic modeling study was undertaken, it was the most recent noise contour study developed from actual operational data and detailed flight track analysis. The results of that analysis were very close to the field measurements taken by the Airport Authority's permanent noise monitors in 1998 and 1999. (Coffman Associates 1998, p. 4-8). Figure 4 shows the 1998 NEM contours, CNEL values at selected points computed using the 1998 NEM data, and the location of the permanent noise monitors.



LEGEND

- Permanent Noise Monitoring Site
- 1998 CNEL at Grid Point
- 1998 Baseline CNEL Contours
- Municipal Boundary
- Airport Boundary
- Housing Value Study Area
- Freeways
- Roads

Sources: Coffman Associates, Burbank-Glendale-Pasadena Airport FAR Part 150 Noise Compatibility Study: Noise Exposure Maps, 1998.

NORTH

0 1,500 3,000 6,000 Feet

Figure 4
1998 NOISE EXPOSURE AND NOISE MONITORING SITES
FAR Part 161 Study for Bob Hope Airport
Technical Report 2
January 2009

JACOBS CONSULTANCY
Airport Management Consulting

The flight track analysis for the 1998 NEM also extends over nearly all of the study area from which housing sales data were drawn. Where necessary, modifications were made to the few flight tracks that did not extend throughout the entire study area. In addition, the aircraft climb profiles in the input database were inspected and extended throughout the entire study area where necessary.

7.0 MODELING APPROACH

An exploratory analysis of the data was carried out and several scatter plots were produced to get insights into the variables and patterns of their relationships. Several combinations of explanatory variables were used and the best model was selected on the basis of overall fit of the model as well as the significance of the independent variables. Appropriate functional specifications were used for the covariates. For example, variables like square footage of house and lot area were converted on a natural logarithm scale to preserve the multiplicative relationship between them and the housing price with a constant elasticity. Pairwise plots of price and explanatory variables were also used as a guide to determine the appropriate specification. Pairwise correlations were also examined while selecting appropriate independent variables for the model to avoid any multi-colinearity problems. Some outliers were removed based on Cook's Distances. Residual analysis was conducted to confirm that there were not any major violations of the normality assumption of the residuals.

When estimating models with numerous variables, the combination or set of variables can be important to the explanatory power of the model. In the exploratory phase of this analysis, several models were estimated using different combinations of independent variables. The statistical significance of the independent variables in each regression was analyzed in the presence or absence of other sets of variables. A final model was selected based on overall fit (adjusted R-squared), the statistical significance of the independent variables, and simplicity in terms of the minimum number of independent variables. The final model included the variables listed in Table 4, below.

Table 4

VARIABLES IN SELECTED HEDONIC HOUSING PRICE MODEL
Bob Hope Airport FAR Part 161 Study

Category	Variable	Category	Variable
Structural	lnL (natural logarithm of lot area)	Neighborhood *(cont'd)*	ES4 (Elementary school – Carpenter Ave)
	lnSF (natural logarithm of square footage of house)		ES6 (Elementary school – Colfax Ave)
	AGE (Age of the building in years)		ES7 (Elementary school – Dixie Canyon Ave)
	HP_N (1 if no pool, 0 ow)		ES16 (Elementary school – Rio Vista)
	B3 (1 if 3 bathrooms, 0 ow)		ES17 (Elementary school – Riverside Dr)
	B4 (1 if 4 bathrooms, 0 ow)		ES19 (Elementary school – Saticoy)
	HC_L (1 if house in low to low-medium quality condition, 0 ow)		ES22 (Elementary school – Toluca Lake)
Neighborhood	F (1 if next to freeway, 0 ow)		CR_P (Crime rate – property)
	ST (1 if on arterial street, 0 ow)	Date of Sale	T2 (1 if sale in 2nd quarter of 1998, 0 ow)
	Q_{ES} (Quality of elementary school)		T3 (1 if sale in 3rd quarter of 1998, 0 ow)
	Q_{ms} (Quality of middle school)		T4 (1 if sale in 4th quarter of 1998, 0 ow)
	HS1 (High school district – Francis Polytechnic)		T5 (1 if sale in 1st quarter of 1998, 0 ow)
	MS1 (Middle school district – Byrd)		T6 (1 if sale in 2nd quarter of 1999, 0 ow)
	MS4 (Middle school district – Millikan)		T7 (1 if sale in 3rd quarter of 1999, 0 ow)
	MS7 (Middle school district – Jordan)		T8 (1 if sale in 4th quarter of 1999, 0 ow)
	ES2 (Elementary school – Burbank Blvd)	Noise	NOISE
			HIGH NOISE

NOTE: "ow" means "otherwise.

Note that the final model excludes several variables that were included in the exploratory tests. These include the number of bedrooms, distance to nearest elementary school, distance to nearest freeway interchange, violent crime rate, and some of the school variables. They were excluded because they either were statistically insignificant or they did not improve the overall goodness of fit (adjusted R^2) of the model to the price data.

It is a standard practice in regression analysis to winnow the independent variables to build a valid, statistically significant and theoretically meaningful model. Including a large number of variables in the regression model simply because they are available is not good practice. This is because all available variables rarely contribute to the effective explanation of the dependent variable (price, in this model). In addition, inclusion of unnecessary variables can cause the estimated parameters to be biased.

Particular problems can be caused by multicollinearity. This condition, where independent variables are highly correlated with each other, can result in one set of variables adding little explanatory power to the model after the inclusion of other highly correlated variables. It can also lead to bias in the coefficients. At the extreme, multicollinearity can involve the "the singularity problem," where a set of variables is selected such that any one of the variables does not provide any additional information over and above its perfectly correlated counterpart. (The singularity problem could arise if, for example, all of the bathroom variables – B1, B2, B3, and B4 – had been included in the model.)

Among the variables excluded from the final model, the number of bedrooms (R) deserves discussion. The number of bedrooms is a commonly used, albeit very rough, layman's indicator of home value. It is frequently correlated, however, with the overall size of the home and the number of bathrooms. In this particular study, it was found that the R variable added negligible explanatory power to the model after the inclusion of the square footage of the house and the number of bathrooms (B3 and B4).

7.1 CNEL Model

After the preliminary review of the data, a hedonic model of the housing market in the Airport area was specified and evaluated in a multiple regression analysis. The CNEL value was used to describe the NOISE variable for this initial analysis.

Table 5 presents the model results and residual plots. The adjusted R^2 is 0.77, showing a good fit of the model to the data. Also, most of the independent variables are statistically significant in helping to explain the dependent variable, with p-values less than 0.001. The table above presents the coefficient estimates along with the t-statistics in the parentheses.

Table 5

RESULTS OF CNEL MODEL

Bob Hope Airport FAR Part 161 Study

Category of Variable	Independent Variable	Estimated Parameter	p-level
	Intercept	6.7292 (38.26)	<0.001
Structural	lnL (natural logarithm of lot area)	0.275 (25.18)	<0.001
	lnSF (natural logarithm of square footage of house)	0.4636 (24.11)	<0.001
	AGE (Age of the building in years)	0.0006 (1.32)	0.186
	HP_N (1 if no pool, 0 ow)	-0.0779 (-6.74)	<0.001
	B3 (1 if 3 bathrooms, 0 ow)	0.0568 (3.77)	<0.001
	B4 (1 if 4 bathrooms, 0 ow)	0.1147 (4.11)	<0.001
	HC_L (1 if house in low to low-medium quality condition, 0 ow)	-0.0413 (-2.82)	0.005
Neighborhood	F (1 if next to freeway, 0 ow)	-0.0547 (-2.64)	0.008
	ST (1 if on arterial street, 0 ow)	-0.094 (-6.05)	<0.001
	Q_{ES} (Quality of elementary school)	0.004 (5.66)	<0.001
	Q_{ms} (Quality of middle school)	0.0055 (7.37)	<0.001
	HS1 (High school district – Francis Polytechnic)	-0.0384 (-2.19)	0.029
	MS1 (Middle school district – Byrd)	-0.0554 (-2.78)	0.006
	MS4 (Middle school district – Millikan)	0.217 (5.99)	<0.001
	MS7 (Middle school district – Jordan)	0.0185 (0.87)	0.383
	ES2 (Elementary school – Burbank Blvd)	0.1797 (6.78)	<0.001
	ES4 (Elementary school – Carpenter Ave)	0.3864 (12.2)	<0.001
	ES6 (Elementary school – Colfax Ave)	0.3936 (18.57)	<0.001
	ES7 (Elementary school – Dixie Canyon Ave)	0.3706 (9.1)	<0.001
	ES16 (Elementary school – Rio Vista)	0.4602 (19.75)	<0.001
	ES17 (Elementary school – Riverside Dr)	0.2677 (7.63)	<0.001
	ES19 (Elementary school – Saticoy)	-0.0839 (-3.36)	<0.001
	ES22 (Elementary school – Toluca Lake)	0.2647 (12.09)	<0.001
Date of Sale	T2 (1 if sale in 2nd quarter of 1998, 0 ow)	0.0559 (3)	0.003
	T3 (1 if sale in 3rd quarter of 1998, 0 ow)	0.1202 (6.48)	<0.001
	T4 (1 if sale in 4th quarter of 1998, 0 ow)	0.129 (6.88)	<0.001
	T5 (1 if sale in 1st quarter of 1998, 0 ow)	0.1296 (6.51)	<0.001
	T6 (1 if sale in 2nd quarter of 1999, 0 ow)	0.1892 (10.3)	<0.001
	T7 (1 if sale in 3rd quarter of 1999, 0 ow)	0.1934 (10.6)	<0.001
	T8 (1 if sale in 4th quarter of 1999, 0 ow)	0.2178 (11.48)	<0.001
Crime	CR_P (Crime rate – property)	-0.0365 (-4.92)	<0.001
Noise	CNEL	-0.0092 (-7.33)	<0.001
	HCNEL (CNEL value if > 65, 0 ow)	0.0019 (4.58)	<0.001
	R^2	0.7747	
	Adjusted R^2	0.7725	

Notes: t statistics are in parentheses; "ow" means "otherwise."

Positive signs of the coefficients for the physical characteristics of the house indicate that the price increases as lot area, square footage and the number of bathrooms increase. The negative coefficients indicate that the prices decrease for homes without a pool and with low to low-medium quality house condition. For the neighborhood characteristics, the price increases with higher quality of elementary and middle schools, but decreases with higher property crime rates and locations next to a freeway or on an arterial street. The school attendance area variables are proxies for other neighborhood characteristics that might not have been explicitly captured, with the coefficients of some having positive signs and of others, negative signs. Finally, the price also increases with decreases in the noise level. Data on other variables like violent crime rate, distance to freeway entrance/exit, municipality, were not found to be statistically significant in explaining price and were excluded from the final model.

7.1.1 Effect of High-Noise Variable

As discussed above, a "high-noise" variable, HCNEL, was included in the model in an attempt to isolate the impact of noise on the value of homes inside the 65 CNEL contour. The variable was defined as follows:

HCNEL = HIGHCNEL x CNEL

where HIGHCNEL is a dummy variable which is 1 if the noise variable is "high" (CNEL > 65) and 0 otherwise.

Thus, the noise coefficient for lower noise levels would be β_{CNEL} and for higher noise levels a combination of β_{CNEL} and β_{HCNEL}. The equation for combining these coefficients is: $\beta_{CNEL} + [100\,(\exp\{\beta_{HCNEL} - 0.5V(\beta_{HCNEL})\} - 1)]$, where "exp" is the exponential expression (e) and V is the variance in β_{HCNEL}.* A very good estimate of the combination, however, can be obtained by simply adding the two coefficients. Thus, in this model, the coefficients are as follows:

Low noise coefficient = -0.0092

High-noise coefficient = -0.0092 + 0.0019 = -0.0073

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* This expression was derived by Kennedy (1981) and confirmed by van Garderen and Shah (2002) as an acceptable approximation to an unbiased estimator of the percentage impact of a dummy variable on a dependent variable. Applying this expression to the data in Table 4 yields the following : NDI (HCNEL) = 100 (exp {0.0019 - 0.5(0.0000002)} - 1) = 0.1902

This is only slightly different than the NDI for HCNEL that would be derived from the raw coefficient shown in the table: 100 x .0019 = 0.1900. This difference is too small to bias the results of the analysis. Thus, the simple summation of the low-noise and high-noise coefficients is used to approximate the NDI for noise levels above 65 CNEL in the rest of this report.

By multiplying each coefficient by 100, they are transformed directly into NDI percentages; i.e., they show the percentage impact on housing price per unit change in CNEL. Thus, the impact on housing price is -0.73% at levels above 65 CNEL.

This finding is consistent with results of the contingent valuation survey undertaken for the FAR Part 161 Study and documented in Appendix E of the FAR Part 161 Application. The survey found that 43% of the residents of acoustically treated homes expressed a willingness to pay for a curfew at the Airport, indicating that the noise discount in property values is not completely eliminated by the treatment program. (See Table E-3 in Appendix E of the FAR Part 161 Application.)

7.2 LEQ_N Model

After defining a hedonic model of housing prices in the Airport area and finding that aircraft noise does have an impact on housing values, the model was tested to determine if **nighttime** aircraft noise, excluding daytime and evening noise, would continue to show an impact. This is necessary to determine whether the results of the hedonic modeling study can be validly used to estimate the potential increase in property values attributable to a nighttime curfew at the Airport. If nighttime noise does not have an impact on property values, it is obvious that a reduction in nighttime Airport noise would have no effect on property values either.

The nighttime Leq metric (LEQ_N) was used as the NOISE variable for this test. Table 6 presents the model results.

The overall model fit, significant variables and the sign of coefficients are similar to those in the CNEL model. The results show that the LEQ_N variable is indeed negatively correlated with property values. The coefficients for "low noise" and "high noise" are as follows:

> Low-noise coefficient (50 decibels and below) = -0.0097
>
> High-noise coefficient (above 50 decibels) = -0.0075

Table 6

RESULTS OF LEQ_N MODEL

Bob Hope Airport FAR Part 161 Study

Category of Variable	Independent Variable	Estimated Parameter	p-level
	Intercept	6.6655 (39.31)	<0.001
Structural	lnL (natural logarithm of lot area)	0.2761 (25.35)	<0.001
	lnSF (natural logarithm of square footage of house)	0.4639 (24.14)	<0.001
	AGE (Age of the building)	0.0005 (1.21)	0.227
	HP_N (1 if no pool, 0 ow)	-0.0776 (-6.72)	<0.001
	B3 (1 if 3 bathrooms, 0 ow)	0.0558 (3.71)	<0.001
	B4 (1 if 4 bathrooms, 0 ow)	0.1119 (4.01)	<0.001
	HC_L (1 if house in poor condition, 0 ow)	-0.0415 (-2.84)	0.005
Neighborhood	F (1 if next to freeway, 0 ow)	-0.0557 (-2.69)	0.007
	ST (1 if on arterial street, 0 ow)	-0.0949 (-6.11)	<0.001
	Q_{ES} (Quality of elementary school)	0.0038 (5.44)	<0.001
	Q_{MS} (Quality of middle school)	0.0056 (7.49)	<0.001
	HS1 (High school district – Francis Polytechnic)	-0.0356 (-2.03)	0.042
	MS1 (Middle school district – Byrd)	-0.0574 (-2.88)	0.004
	MS4 (Middle school district -- Millikan)	0.2169 (5.99)	<0.001
	MS7 (Middle school district – Jordan)	0.019 (0.91)	0.362
	ES2 (Elementary school – Burbank Blvd)	0.1736 (6.53)	<0.001
	ES4 (Elementary school – Carpenter Ave)	0.3876 (12.24)	<0.001
	ES6 (Elementary school – Colfax Ave)	0.3939 (18.6)	<0.001
	ES7 (Elementary school – Dixie Canyon Ave)	0.3721 (9.14)	<0.001
	ES16 (Elementary school – Rio Vista)	0.4547 (19.44)	<0.001
	ES17 (Elementary school – Riverside Dr)	0.269 (7.67)	<0.001
	ES19 (Elementary school – Saticoy)	-0.0855 (-3.42)	<0.001
	ES22 (Elementary school – Toluca Lake)	0.2628 (12.01)	<0.001
Date of Sale	T2 (1 if sale in 2nd quarter of 1998, 0 ow)	0.0562 (3.02)	0.003
	T3 (1 if sale in 3rd quarter of 1998, 0 ow)	0.1207 (6.51)	<0.001
	T4 (1 if sale in 4th quarter of 1998, 0 ow)	0.1295 (6.91)	<0.001
	T5 (1 if sale in 1st quarter of 1998, 0 ow)	0.1315 (6.62)	<0.001
	T6 (1 if sale in 2nd quarter of 1999, 0 ow)	0.1914 (10.43)	<0.001
	T7 (1 if sale in 3rd quarter of 1999, 0 ow)	0.1956 (10.73)	<0.001
	T8 (1 if sale in 4th quarter of 1999, 0 ow)	0.2195 (11.58)	<0.001
Crime	CR_P (Crime rate - property)	-0.0385 (-5.18)	<0.001
Noise	LEQ_N	-0.0097 (-7.68)	<0.001
	$HLEQ_N$ (LEQ_N value if > 50, 0 ow)	0.0022 (4.69)	<0.001
	R^2	0.7750	
	Adjusted R^2	0.7728	

Notes: t statistics are in parentheses; “ow” means “otherwise.”

7.3 HA Model

After defining a hedonic model of the local housing market and verifying that nighttime noise was indeed a contributor to the effect of aircraft noise on housing values, the model was tested by substituting alternative descriptors of the NOISE variable. Table 7 presents the results using the HA descriptor.

The model fit, significant variables and the sign of coefficients are similar to those in the CNEL model. The noise coefficients are -0.0178 and -0.0034 for low and high noise levels, respectively.

Table 7

RESULTS OF HA MODEL
Bob Hope Airport FAR Part 161 Study

Category of Variable	Independent Variable	Estimated Parameter	p-level
	Intercept	6.2459 (41.14)	<0.001
Structural	lnL (natural logarithm of lot area)	0.28 (25.8)	<0.001
	lnSF (natural logarithm of square footage of house)	0.4653 (24.21)	<0.001
	AGE (Age of the building)	0.0005 (1.12)	0.263
	HP_N (1 if no pool, 0 ow)	-0.0795 (-6.88)	<0.001
	B3 (1 if 3 bathrooms, 0 ow)	0.0579 (3.85)	<0.001
	B4 (1 if 4 bathrooms, 0 ow)	0.1165 (4.17)	<0.001
	HC_L (1 if house in poor condition, 0 ow)	-0.0423 (-2.89)	0.004
Neighborhood	F (1 if next to freeway, 0 ow)	-0.0564 (-2.72)	0.006
	ST (1 if on arterial street, 0 ow)	-0.0903 (-5.83)	<0.001
	Q_{ES} (Quality of elementary school)	0.004 (5.71)	<0.001
	Q_{MS} (Quality of middle school)	0.0055 (7.39)	<0.001
	HS1 (High school district – Francis Polytechnic)	-0.0418 (-2.39)	0.017
	MS1 (Middle school district – Byrd)	-0.0548 (-2.75)	0.006
	MS4 (Middle school district – Millikan)	0.215 (5.93)	<0.001
	MS7 (Middle school district – Jordan)	0.0472 (2.45)	0.014
	ES2 (Elementary school – Burbank Blvd)	0.1729 (6.5)	<0.001
	ES4 (Elementary school – Carpenter Ave)	0.3893 (12.29)	<0.001
	ES6 (Elementary school -- Colfax Ave)	0.3819 (18.1)	<0.001
	ES7 (Elementary school – Dixie Canyon Ave)	0.3615 (8.9)	<0.001
	ES16 (Elementary school – Rio Vista)	0.468 (20.3)	<0.001
	ES17 (Elementary school – Riverside Dr)	0.2596 (7.42)	<0.001
	ES19 (Elementary school – Saticoy)	-0.0857 (-3.43)	<0.001
	ES22 (Elementary school – Toluca Lake)	0.264 (12.06)	<0.001
Date of Sale	T2 (1 if sale in 2nd quarter of 1998, 0 ow)	0.0555 (2.98)	0.003
	T3 (1 if sale in 3rd quarter of 1998, 0 ow)	0.1199 (6.47)	<0.001
	T4 (1 if sale in 4th quarter of 1998, 0 ow)	0.1292 (6.89)	<0.001
	T5 (1 if sale in 1st quarter of 1998, 0 ow)	0.1321 (6.64)	<0.001
	T6 (1 if sale in 2nd quarter of 1999, 0 ow)	0.1912 (10.42)	<0.001
	T7 (1 if sale in 3rd quarter of 1999, 0 ow)	0.195 (10.69)	<0.001
	T8 (1 if sale in 4th quarter of 1999, 0 ow)	0.2197 (11.59)	<0.001
Crime	CR_P (Crime rate – property)	-0.0373 (-5.02)	<0.001
Noise	HA	-0.0178 (-7.57)	<0.001
	HHA (HA value if > 12.29, 0 ow)	0.0144 (6.43)	<0.001
	R^2	0.7749	
	Adjusted R^2	0.7727	

Notes: t statistics are in parentheses; "ow" means "otherwise."

7.4 HA_{FS} Model

Table 8 presents the model results where the HA_{FS} noise descriptor was used. The model fit, significant variables and the sign of coefficients are similar to those in the HA and CNEL models. The noise coefficients are -0.0104 and -0.0048 for low and high noise levels respectively.

Table 8

RESULTS OF HA_{FS} MODEL

Bob Hope Airport FAR Part 161 Study

Category of Variable	Independent Variable	Estimated Parameter	p-level
	Intercept	6.3745 (41.12)	<0.001
Structural	lnL (natural logarithm of lot area)	0.2767 (25.45)	<0.001
	lnSF (natural logarithm of square footage of house)	0.4642 (24.17)	<0.001
	AGE (Age of the building)	0.0005 (1.24)	0.215
	HP_N (1 if no pool, 0 ow)	-0.0788 (-6.83)	<0.001
	B3 (1 if 3 bathrooms, 0 ow)	0.0569 (3.78)	<0.001
	B4 (1 if 4 bathrooms, 0 ow)	0.1149 (4.12)	<0.001
	HC_L (1 if house in poor condition, 0 ow)	-0.0412 (-2.82)	0.005
Neighborhood	F (1 if next to freeway, 0 ow)	-0.0555 (-2.68)	0.007
	ST (1 if on arterial street, 0 ow)	-0.0932 (-6.01)	<0.001
	Q_{ES} (Quality of elementary school)	0.0039 (5.51)	<0.001
	Q_{MS} (Quality of middle school)	0.0055 (7.47)	<0.001
	HS1 (High school district – Francis Polytechnic)	-0.0401 (-2.29)	0.022
	MS1 (Middle school district – Byrd)	-0.056 (-2.81)	0.005
	MS4 (Middle school district – Millikan)	0.216 (5.97)	<0.001
	MS7 (Middle school district – Jordan)	0.0259 (1.27)	0.203
	ES2 (Elementary school – Burbank Blvd)	0.1738 (6.55)	<0.001
	ES4 (Elementary school – Carpenter Ave)	0.3897 (12.31)	<0.001
	ES6 (Elementary school – Colfax Ave)	0.3903 (18.48)	<0.001
	ES7 (Elementary school – Dixie Canyon Ave)	0.3698 (9.1)	<0.001
	ES16 (Elementary school – Rio Vista)	0.461 (19.89)	<0.001
	ES17 (Elementary school – Riverside Dr)	0.2656 (7.59)	<0.001
	ES19 (Elementary school – Saticoy)	-0.0878 (-3.52)	<0.001
	ES22 (Elementary school – Toluca Lake)	0.2644 (12.09)	<0.001
Date of Sale	T2 (1 if sale in 2nd quarter of 1998, 0 ow)	0.0558 (3)	0.003
	T3 (1 if sale in 3rd quarter of 1998, 0 ow)	0.1202 (6.49)	<0.001
	T4 (1 if sale in 4th quarter of 1998, 0 ow)	0.129 (6.89)	<0.001
	T5 (1 if sale in 1st quarter of 1998, 0 ow)	0.1305 (6.57)	<0.001
	T6 (1 if sale in 2nd quarter of 1999, 0 ow)	0.1897 (10.34)	<0.001
	T7 (1 if sale in 3rd quarter of 1999, 0 ow)	0.1938 (10.64)	<0.001
	T8 (1 if sale in 4th quarter of 1999, 0 ow)	0.2179 (11.5)	<0.001
Crime	CR_P (Crime rate - property)	-0.0373 (-5.04)	<0.001
Noise	HA_{FS}	-0.0104 (-7.89)	<0.001
	HHA_{FS} (HA_{FS} value if > 27.31, 0 ow)	0.0057 (5.75)	<0.001
	R^2	0.7752	
	Adjusted R^2	0.7731	

Notes: t statistics in parentheses; "ow" means "otherwise."

7.5 HA_{MO} Model

Table 9 presents the results for the model where the HA_{MO} noise descriptor was used. The model fit, significant variables and the sign of coefficients are similar to those in the HA and HA_{FS} models. The noise coefficients are -0.0079 and -0.0024 for low and high noise levels respectively.

Table 9

RESULTS OF HA_{MO} MODEL
Bob Hope Airport FAR Part 161 Study

Category of Variable	Independent Variable	Estimated Parameter	p-level
	Intercept	6.305 (41.29)	<0.001
Structural	lnL (natural logarithm of lot area)	0.277 (25.5)	<0.001
	lnSF (natural logarithm of square footage of house)	0.4642 (24.18)	<0.001
	AGE (Age of the building)	0.0005 (1.22)	0.224
	HP_N (1 if no pool, 0 ow)	-0.079 (-6.85)	<0.001
	B3 (1 if 3 bathrooms, 0 ow)	0.057 (3.79)	<0.001
	B4 (1 if 4 bathrooms, 0 ow)	0.1148 (4.12)	<0.001
	HC_L (1 if house in poor condition, 0 ow)	-0.041 (-2.8)	0.005
Neighborhood	F (1 if next to freeway, 0 ow)	-0.0551 (-2.67)	0.008
	ST (1 if on arterial street, 0 ow)	-0.0931 (-6.02)	<0.001
	Q_{ES} (Quality of elementary school)	0.0038 (5.46)	<0.001
	Q_{MS} (Quality of middle school)	0.0055 (7.49)	<0.001
	HS1 (High school district – Francis Polytechnic)	-0.0403 (-2.3)	0.021
	MS1 (Middle school district – Byrd)	-0.0564 (-2.83)	0.005
	MS4 (Middle school district – Millikan)	0.2153 (5.95)	<0.001
	MS7 (Middle school district – Jordan)	0.0264 (1.31)	0.190
	ES2 (Elementary school – Burbank Blvd)	0.1726 (6.5)	<0.001
	ES4 (Elementary school – Carpenter Ave)	0.3906 (12.35)	<0.001
	ES6 (Elementary school – Colfax Ave)	0.3908 (18.5)	<0.001
	ES7 (Elementary school – Dixie Canyon Ave)	0.3706 (9.12)	<0.001
	ES16 (Elementary school – Rio Vista)	0.4607 (19.9)	<0.001
	ES17 (Elementary school – Riverside Dr)	0.2656 (7.59)	<0.001
	ES19 (Elementary school – Saticoy)	-0.0894 (-3.58)	<0.001
	ES22 (Elementary school – Toluca Lake)	0.2645 (12.1)	<0.001
Date of Sale	T2 (1 if sale in 2nd quarter of 1998, 0 ow)	0.0559 (3.01)	0.003
	T3 (1 if sale in 3rd quarter of 1998, 0 ow)	0.1205 (6.51)	<0.001
	T4 (1 if sale in 4th quarter of 1998, 0 ow)	0.1291 (6.9)	<0.001
	T5 (1 if sale in 1st quarter of 1998, 0 ow)	0.131 (6.6)	<0.001
	T6 (1 if sale in 2nd quarter of 1999, 0 ow)	0.1899 (10.36)	<0.001
	T7 (1 if sale in 3rd quarter of 1999, 0 ow)	0.194 (10.65)	<0.001
	T8 (1 if sale in 4th quarter of 1999, 0 ow)	0.218 (11.51)	<0.001
Crime	CR_P (Crime rate - property)	-0.0376 (-5.07)	<0.001
Noise	HA_{MO}	-0.0079 (-8.1)	<0.001
	HHA_{MO} (HA_{MO} value if > 27.76, 0 ow)	0.0055 (5.89)	<0.001
	R^2	0.7754	
	Adjusted R^2	0.7733	

Notes: t statistics in parentheses; "ow" means "otherwise."

7.6 NDI Calculations

The general functional form of the models can be represented as:

$$\ln(P) = \beta_0 + \beta_1 \ln(X) + \beta_2 Y + \beta_3 Z + \beta_4 \text{NOISE} + \varepsilon$$

where X, Y, and Z are the set of covariates concerned with physical characteristics lot, house, and neighborhood. The β's are the estimated parameters and ε is the stochastic error term. β_4 is the estimated coefficient for the noise variable.

The Noise Depreciation Index (NDI) is defined as the percentage rate of discount in property value per decibel increase in noise. Taking partial derivatives in the equation above:

$$\beta_4 = \frac{1}{P}\frac{\partial P}{\partial \text{NOISE}}$$

Hence, for the CNEL model, the noise coefficient converted to a percentage can be directly read as the NDI. However, the NOISE coefficients for the HA, HA_{FS} and HA_{MO} models, show the percentage rate of discount per unit increase in HA (or HA_{FS} or HA_{MO}). To compute the NDI, a conversion factor must be applied, as follows:

NDI = % change in P per unit increase in dB = (% change in P per unit increase in HA) * (change in HA per unit increase in dB) = ($100\beta_3$) * (HA to dB conversion factor)

The conversion factors are computed from the equations for the HA, HA_{FS} and HA_{MO} curves as described earlier. Due to the non-linear relationship of HA to noise level, the conversion factor varies by CNEL and so does the NDI. Table 10 and Figure 5 present the summary of NDIs derived from the regression models.

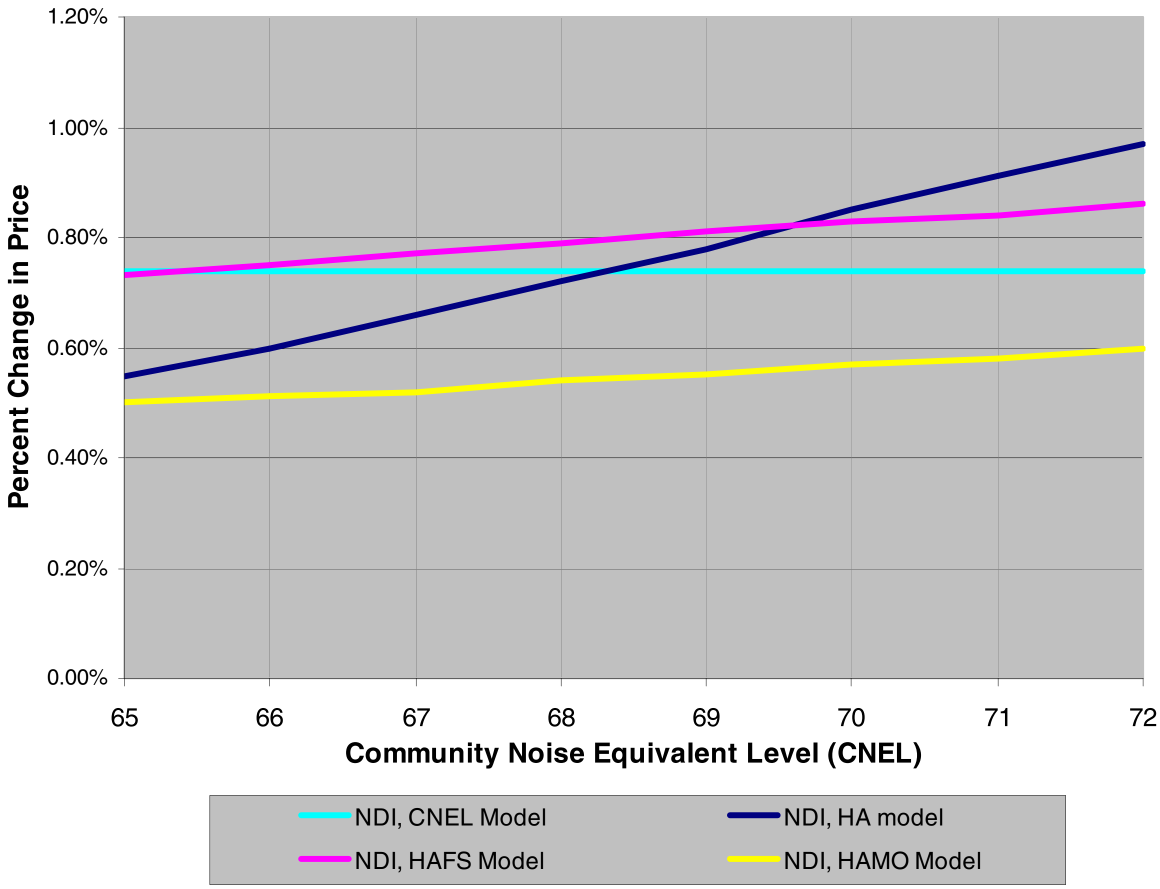
Table 10

COMPARISON OF NDIs FROM VARIOUS REGRESSION MODELS
Bob Hope Airport FAR Part 161 Study

	Regression Model							
	Ln(P) vs. CNEL		ln(P) vs. HA		ln(P) vs. HA_{FS}		ln(P) vs. HA_{MO}	
	CNEL	NDI	HA	NDI	HA_{FS}	NDI	HA_{MO}	NDI
	65	0.74%	12.31	0.55%	27.32	0.73%	27.78	0.50%
	66	0.74%	13.90	0.60%	28.82	0.75%	29.79	0.51%
	67	0.74%	15.67	0.66%	30.39	0.77%	31.88	0.52%
	68	0.74%	17.62	0.72%	32.00	0.79%	34.03	0.54%
	69	0.74%	19.77	0.78%	33.65	0.81%	36.24	0.55%
	70	0.74%	22.10	0.85%	35.34	0.83%	38.51	0.57%
Average NDI		0.74%		0.75%		0.80%		0.55%

Figure 5

COMPARISON OF NDIs FROM ALTERNATIVE MODELS
Bob Hope Airport FAR Part 161 Study



Source: Jacobs Consultancy analysis, 2007.

8.0 DISCUSSION AND CONCLUSIONS

Several regression models were estimated to quantify the impact of noise on property values in the Bob Hope Airport vicinity. Models were estimated using different noise variables in succession – four 24-hour noise metrics and one nighttime noise metric.

All models produced similar findings, showing that as noise decreases, property values increase. The model using nighttime noise, LeqN, found that nighttime noise was correlated with property values in a similar way as the 24-hour noise descriptors. This provides clear evidence that nighttime aircraft noise influences housing prices and that property value impacts are not due solely to the daytime and evening noise reflected in the 24-hour noise metrics.

To account for different impacts of noise on property values at high and low noise levels, a high-noise variable was used in the regression models. "High noise" was defined as "above 65 CNEL." The discount in price for a unit increase in noise level is smaller at higher noise levels. The evidence indicates that this is capturing the ameliorating effect of the residential acoustical treatment program.

The four models that used the 24-hour noise descriptors (CNEL and the three HA metrics) all have a good fit and include many significant covariates that help explain the housing price variable. The adjusted R^2 for all four models is .773. They differ from each other only at the fourth decimal place. The estimated parameters for the explanatory variables are stable across the models as the noise variable is changed, indicating the robustness of the models. Thus, all specifications of the model described in this report show that aircraft noise, regardless of how it is described, influences residential property values in the local area.

In conclusion, all four models are statistically valid and theoretically defensible. Thus, all are used to develop alternate estimates of the potential increase in property values attributable to the alternative curfews being evaluated in the Part 161 Study. This is documented in Appendix D of the FAR Part 161 Application.

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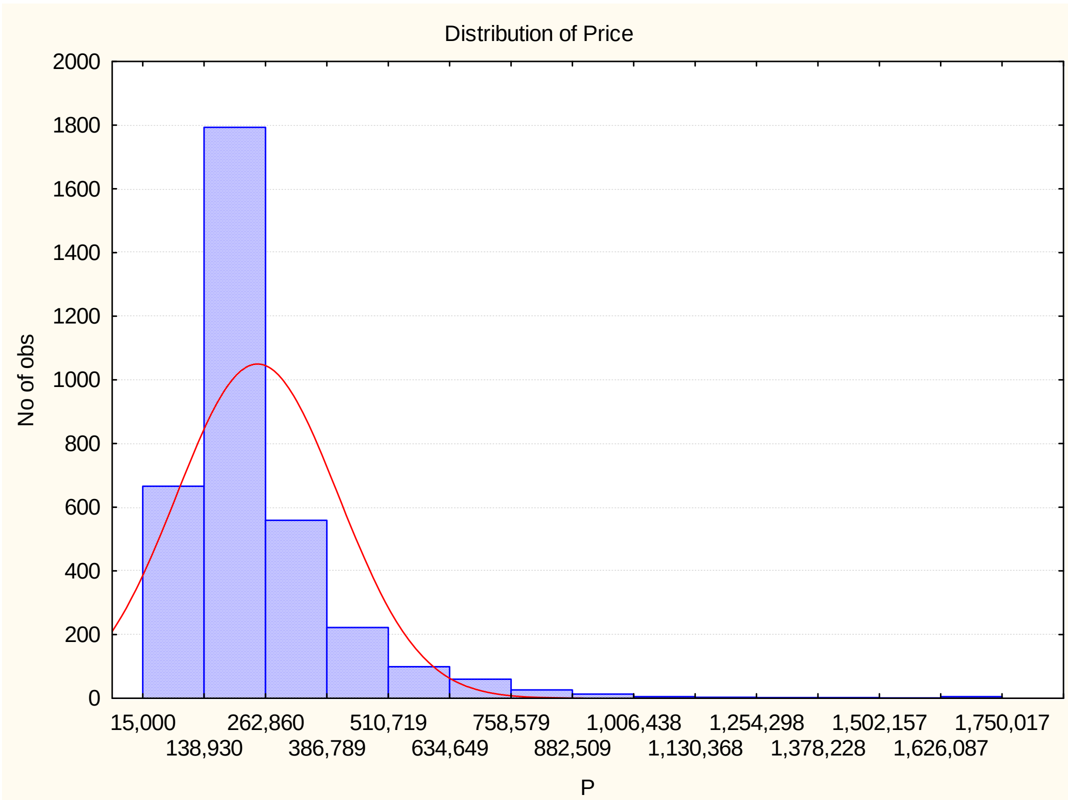
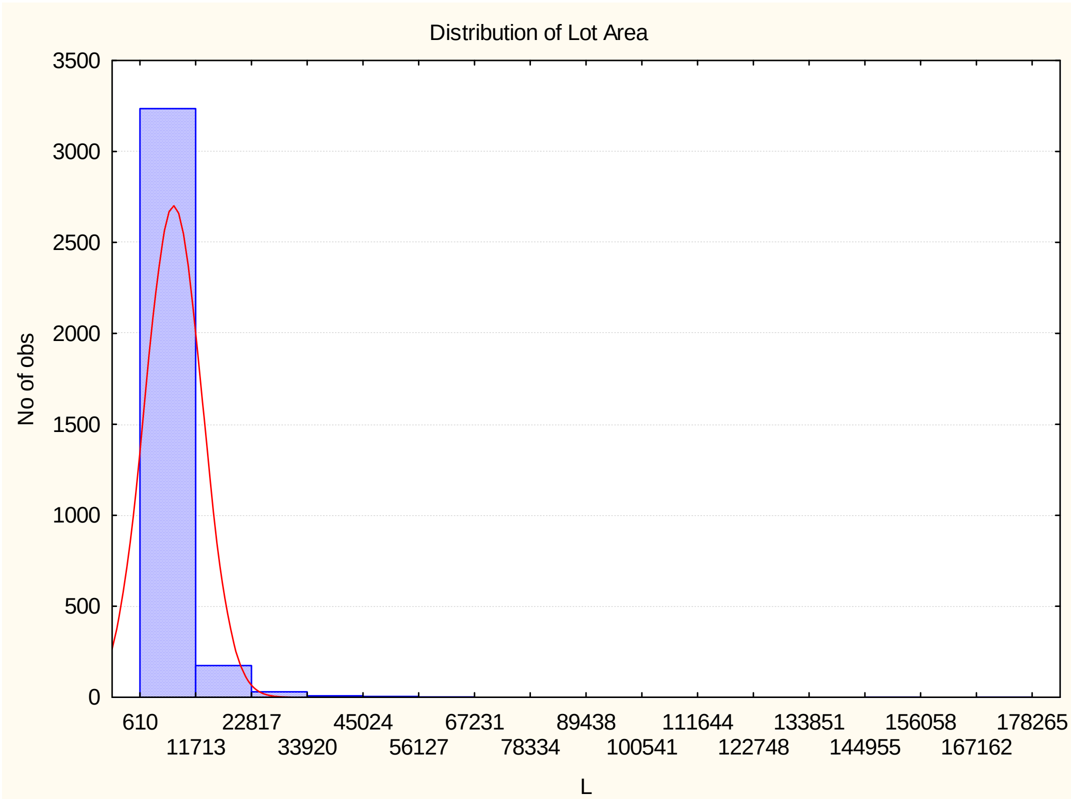
APPENDIX

EXPLORATORY ANALYSIS

Distributions of Selected Variables





Distribution of Lot Area
No of obs
3500
3000
2500
2000
1500
1000
500
0
610
11713
22817
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133851
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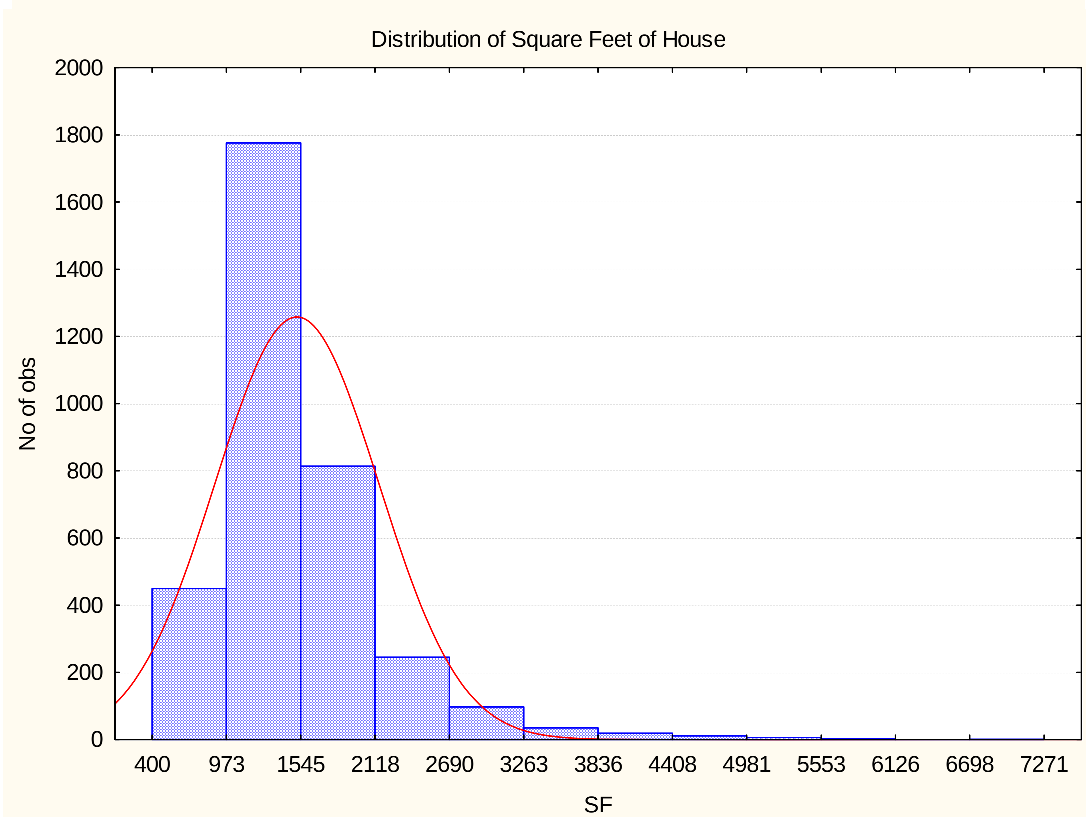

Distribution of Square Feet of House
No of obs
2000
1800
1600
1400
1200
1000
800
600
400
200
0
400
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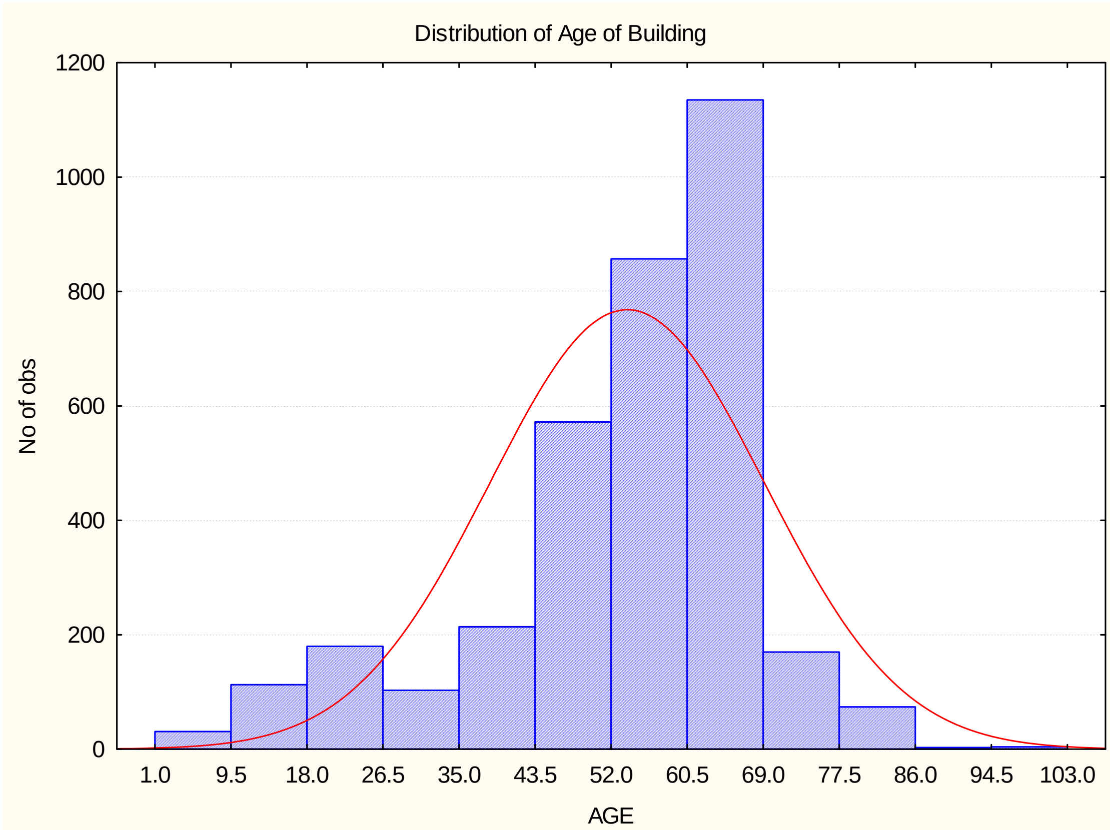
1545
2118
2690
3263
3836
4408
4981
5553
6126
6698
7271
SF


Distribution of Age of Building
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1000
800
600
400
200
0
No of obs
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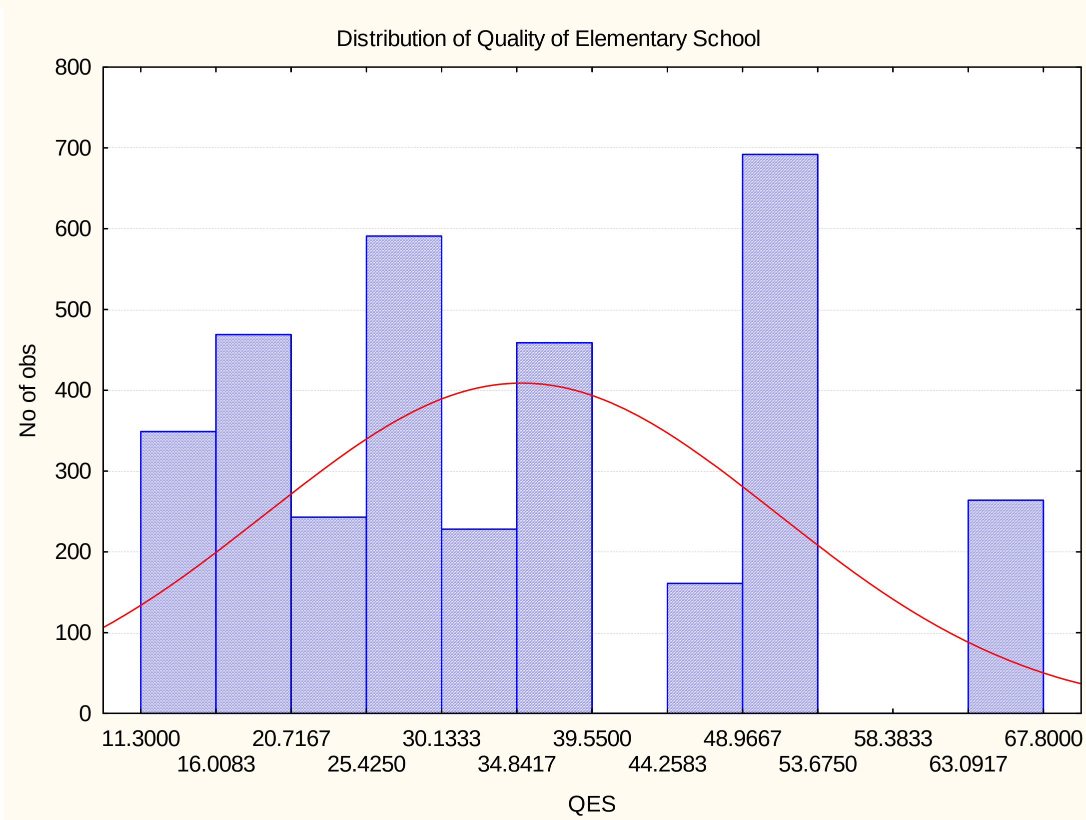
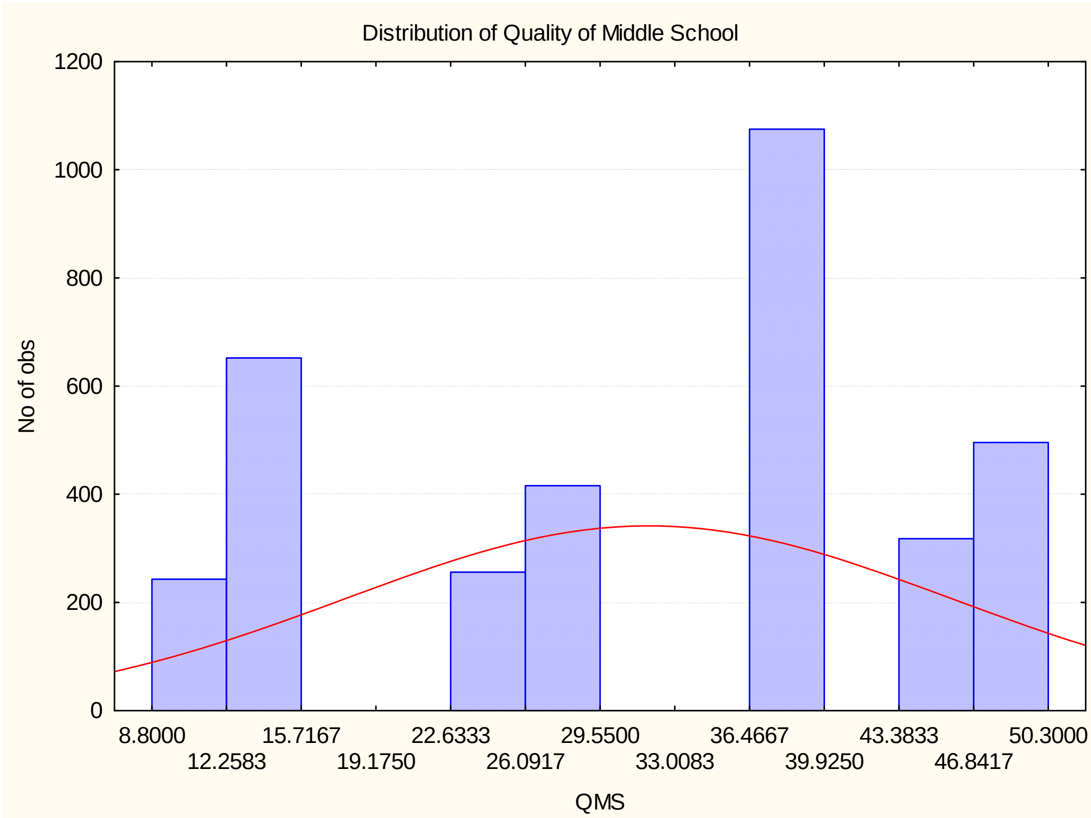
9.5
18.0
26.5
35.0
43.5
52.0
60.5
69.0
77.5
86.0
94.5
103.0
AGE


Distribution of Quality of Elementary School
800
700
600
500
400
300
200
100
0
No of obs
11.3000
16.0083
20.7167
25.4250
30.1333
34.8417
39.5500
44.2583
48.9667
53.6750
58.3833
63.0917
67.8000
QES


Distribution of Quality of Middle School
No of obs
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200
400
600
800
1000
1200
8.8000
12.2583
15.7167
19.1750
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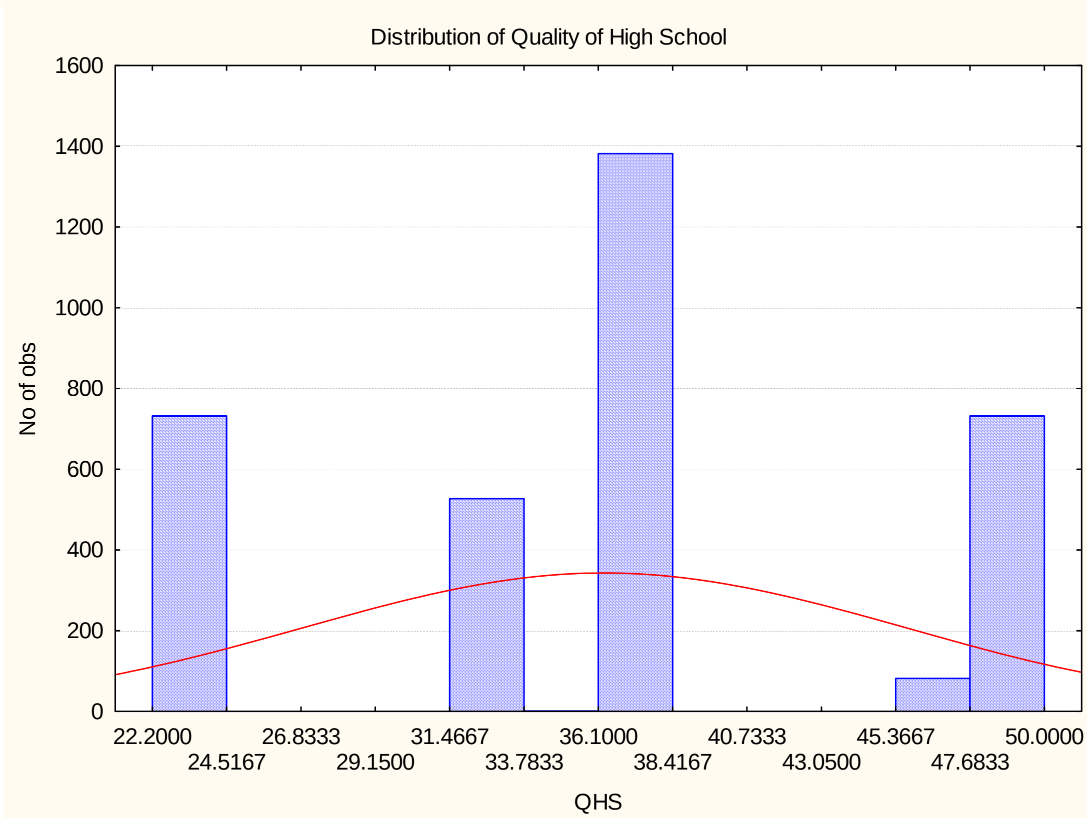
46.8417
50.3000
QMS


Distribution of Quality of High School
No of obs
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400
600
800
1000
1200
1400
1600
22.2000
24.5167
26.8333
29.1500
31.4667
33.7833
36.1000
38.4167
40.7333
43.0500
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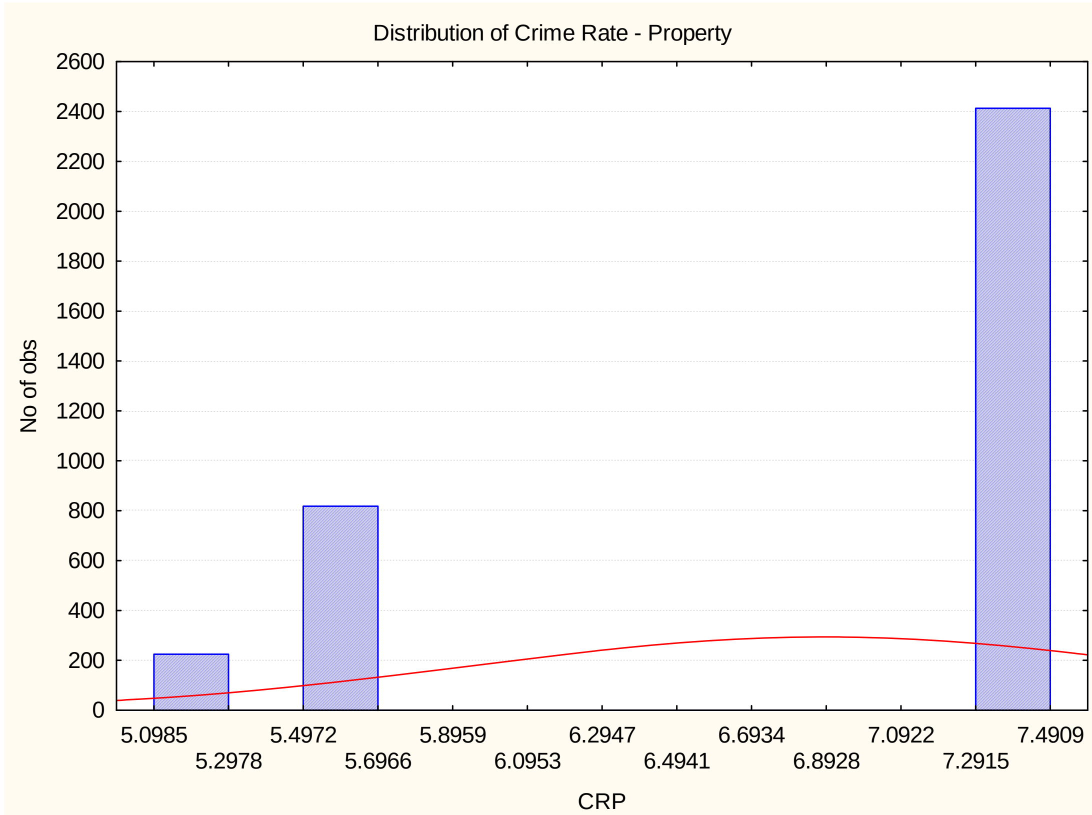
47.6833
50.0000
QHS


Distribution of Crime Rate - Property
No of obs
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2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
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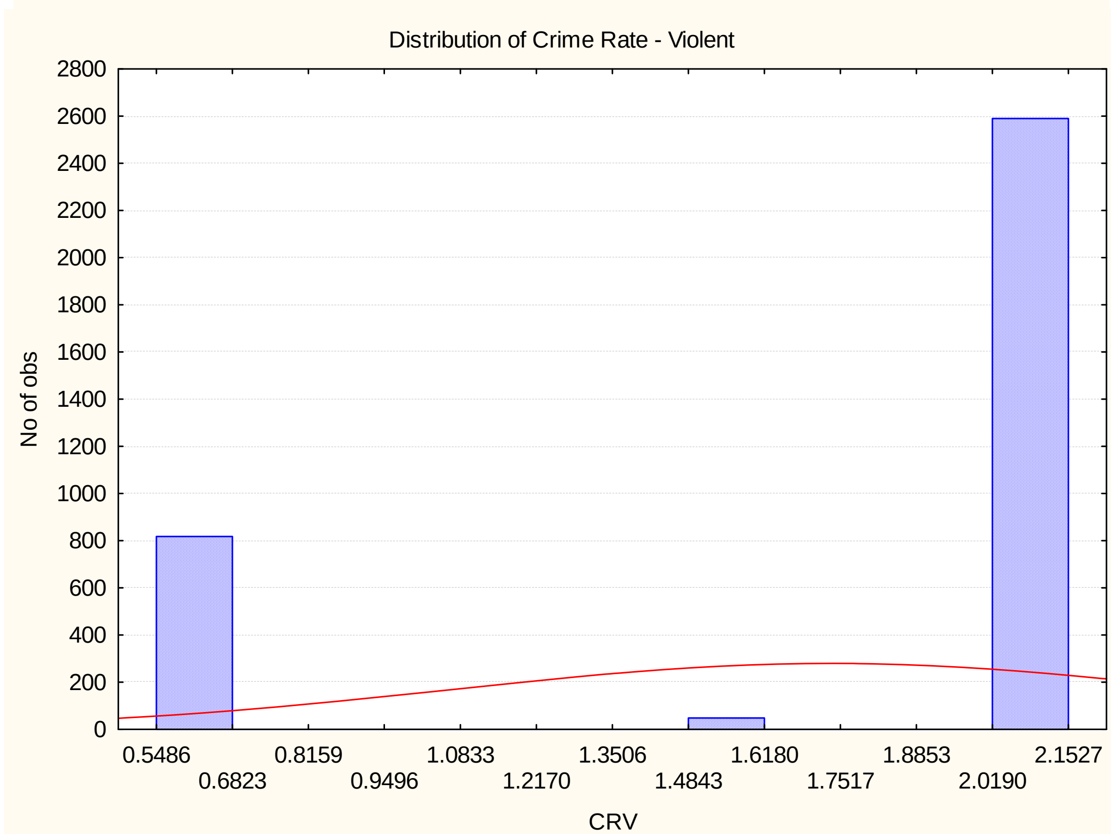
5.2978
5.4972
5.6966
5.8959
6.0953
6.2947
6.4941
6.6934
6.8928
7.0922
7.2915
7.4909
CRP


Distribution of Crime Rate - Violent
No of obs
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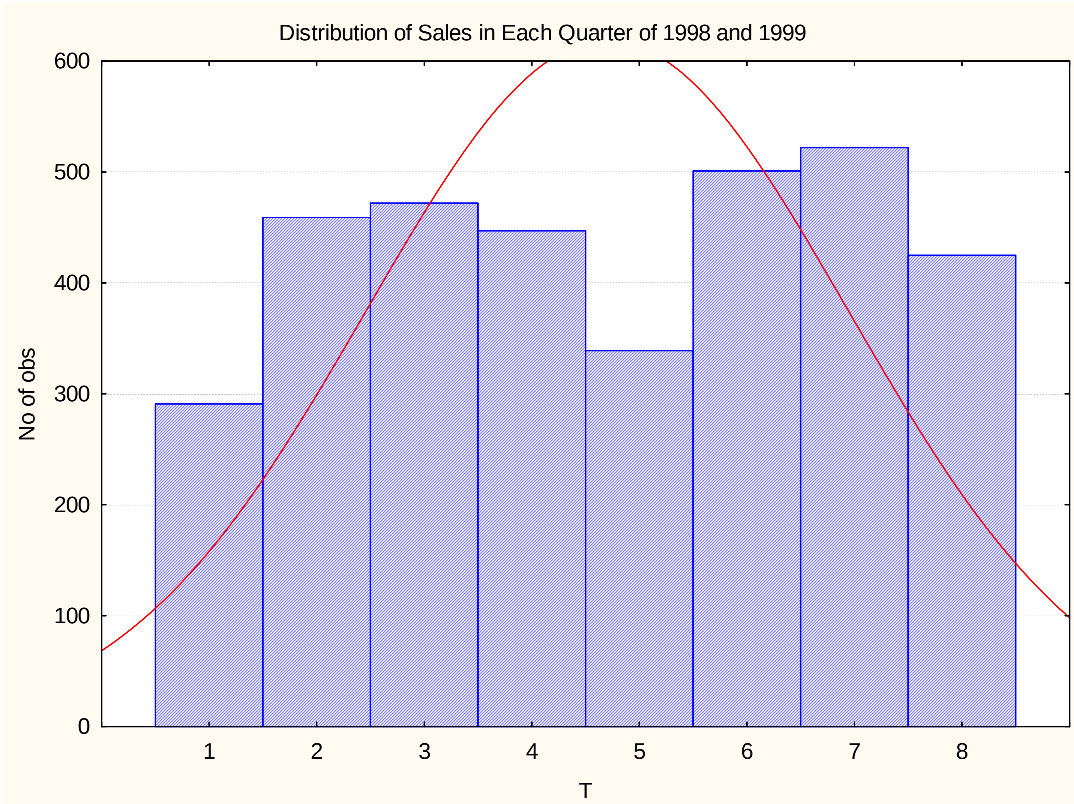
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0.5486
0.6823
0.8159
0.9496
1.0833
1.2170
1.3506
1.4843
1.6180
1.7517
1.8853
2.0190
2.1527
CRV


Distribution of Sales in Each Quarter of 1998 and 1999
600
500
400
300
200
100
0
No of obs
1
2
3
4
5
6
7
8
T