Modeling Spatial Impacts of Siting a NIMBY Facility

MUSHTAQUR RAHMAN, A. ESSAM RADWAN, JONATHAN UPCHURCH, AND MICHAEL KUBY

In the new era of environmental and growth management concerns, the task of locating a socially undesirable facility, such as a solid waste management (SWM) facility, encompasses not only minimizing cost objectives, but also minimizing the effects on and opposition from residential neighborhoods. Survey research on awareness of the existence of such facilities, contemporary attitudes toward solid waste management facilities and their impacts and preferences for various facility attributes, such as number and size, are discussed. In addition, a distance decay effect of people's attitudes toward both existing and to-be-built SWM facilities is identified. These distance-decay results contribute to the literature on the spatial extent of perceived impact of and opposition to undesirable facilities, especially for previously unstudied transfer stations. The data collection and analysis methods selected for this study are discussed. Several binomial and multinomial logit models were developed to model the spatial effects of siting SWM facilities. The most prominent effect of an SWM facility was determined to be the perceived threat to residential property value. Other perceived effects, such as quality of life, traffic accidents, and relocation, did not seem to have a major effect on people.

A solid waste management (SWM) facility, popularly known as a transfer station, can be defined as a NIMBY (not in my back yard) or undesirable facility because people do not want them located nearby. A transfer station is a transshipment point between refuse collection points and final disposal sites. It has been demonstrated in past research (*1*) that a solid waste collection system can be made efficient by locating transfer stations within a city or region in which collection vehicles can transfer their loads to large-size transport vehicles.

The undesirable characteristics of a transfer station primarily affect the individuals in the host community who are located near them. These effects include noisy and possibly dangerous movement of the collection and transfer vehicles, odor pollution at the transfer site, and reduced property value caused by negative perceptions of image or risk or both. These effects depend mostly on the design and operational characteristics of a particular facility.

The location of transfer facilities presents spatial conflicts among the areas served by the facility. For example, a transfer station should typically be located near a given set of refuse collection points to achieve cost-efficiency. Simultaneously, it should be located far enough from the residential areas to minimize real or perceived population impacts and potential opposition. Clearly, these two objectives pose spatial conflict and thus require some trade-offs for finding a compromise location. Rahman (*2*) developed and implemented a model to resolve such facility location problems through the use of multiobjective programming. This paper reports on the part of that effort where distance-based logit equations were developed from survey results, in part to provide input into the opposition-minimizing objective.

This research contributes empirical results to an emerging paradigm in which public opposition is considered in location modeling through maximization of distance-related measures. Erkut and Neuman (*3*) recently published an invited review of the literature on models for locating undesirable facilities. These papers assume a variety of ways to make operational this concept of putting the facilities far from the residential population. Some maximize the average separation distance, some maximize the minimum separation distance, and others minimize the number of people within some critical distance or impact radius. Of the 64 modeling papers reviewed by Erkut and Neuman, none, so far as we know, bases their considerations on any empirical results regarding the spatial extent of negative effects around a NIMBY facility.

A review of existing literature reveals that the empirical studies on the impact of undesirable facilities have thus far focused on estimating actual residential property-value depreciation, with relatively little information concerning perceived effects and their spatial distribution. Also, the impacts of transfer stations have rarely been studied. Zeiss and Atwater (*4*) reviewed 13 empirical studies to determine property value impacts around landfill and incinerator sites. Most of these studies investigated property sale prices around either landfills or power plants and then made comparisons of prices from control locations to identify any trend in property-value differential. One study mentions Price, as quoted in Zeiss and Atwater (*4*), and included transfer stations in an investigation of the property-value depreciation. The findings of these studies are mixed and show no consistent trend of positive or negative effects on property values. In another paper dealing with incinerator impacts, Zeiss (*5*) reported weak correlation between the number of days required to sell properties and the distance from the incinerator. All these studies primarily dealt with the subject of actual property-value impact by investigating actual property sale prices and did not study the perceived property-value impact. However, recent research (*6*) shows that perceived property value impacts exist among

M. Rahman, JHK & Associates, 16000 Christensen Road, Suite 304, Seattle, Wash. 98188. A. E. Radwan, Department of Civil and Environmental Engineering, University of Central Florida, Orlando, Fla. 32816. J. Upchurch, Center for Advanced Research in Transportation, and M. Kuby, Department of Geography, Arizona State University, Tempe, Ariz. 85287.

host community residents, and monetary compensations often may not be enough for acceptance of waste disposal facilities. The research reported in this paper covered the topic of perceived property value impact and its spatial distribution.

Some prior studies (*7*) investigated the spatial distribution of perceived risks and perceived benefits. However, these studies were associated with hazardous waste facilities and industries handling toxic materials. The findings were presented in terms of cumulative percentages of persons willing to live at various distances from the hazardous facilities. No attempt was made to fit any distance-decay equations to the data sets.

Another research direction in undesirable facility location modeling (*8*) has been the effect of facility scale on opposition and the related notion of risk sharing among many smaller facilities. In this paper, we present some preliminary, although inconclusive, empirical results relating to these ideas.

RESEARCH OBJECTIVES

The research reported in this paper was undertaken to gain a sense of contemporary attitudes toward solid waste management facilities and to test some hypotheses on preferences for various facility attributes. The five main hypotheses tested in this research are as follows:

1. People perceive negative impacts of SWM facilities relating to traffic accidents, property values, and quality of life.
2. The negative attitudes people have toward SWM facilities decay with increasing distance from the facilities.
3. Awareness of the existence of SWM facilities declines with increasing distance from the facilities.
4. People would prefer small-sized SWM facilities dispersed in several communities over a single large facility.
5. People would prefer temporary SWM facilities over permanent ones.

The second hypothesis listed above represents the focal point of this research and was intended to explore whether or not a distance decay effect existed for people's negative attitudes toward an SWM facility. The motivation came mainly from the need for an appropriate distance-based objective function for the location problem.

Two attitudinal surveys were conducted to investigate negative public perceptions surrounding an existing small-size (300 tons/day) SWM facility in the city of Glendale and to a to-be-built facility in the city of Phoenix. Two surveys were conducted to offer two tests of the hypotheses.

The Glendale facility is located in the city's office yard and has been operational for the last 15 years. The selected site for the Phoenix SWM facility, known as the Southwest Transfer Station, is near the city's 27th Avenue landfill. Soon Phoenix will use its new landfill, 45 mi southwest of the current landfill.

DATA COLLECTION

The data for this study were collected in two telephone surveys conducted in Glendale and Phoenix, Ariz. The focus population group in Glendale consisted of those living close to the existing solid waste management facility. For the Phoenix survey, the focus was on those living close to the site on which such a facility was to be constructed about 1 year after the survey. Each survey covered six census tracts surrounding the facilities. A demographic profile of these census tracts is presented in Table 1.

The final sample sizes achieved were 294 for the Glendale survey and 254 for the Phoenix survey. These samples provided estimates on population proportions with certain characteristics accurate to within 6 percent at 95 percent confidence level.

Cole's reverse telephone directory (*9*) was used to generate the sampling pool. The sampling method used for this study can be termed "proportionate stratified sampling," in which a strata is a population subgroup defined over census tracts. The sample needed to be stratified by census tracts because separate lists are available in the *Cole's Directory* for each census tract, and it was easier to draw separate samples than to combine the lists.

The items in the surveys can be categorized into the following four groups:

1. Awareness about the facility: one question to determine whether the respondent has previous knowledge of the facility.
2. Measure of potential opposition (MPO) for a new SWM facility: one question measuring perceived comfortable dis-

TABLE 1 Census Tract Statistics

Census Tract No	Wealth Rating	Median Age	Median # Persons per H.H.	% Owner Occupied H.H.	Median Yrs in School	Total Res. H.H.	Total Business
(a) City of Glendale							
926	2	50	2.3	53	12.1	911	317
928	1	42	2.7	45	12.3	1,821	136
923.02	4	39	2.9	79	12.9	3,264	160
925	1	54	2.5	60	12.2	1,149	538
923.01	3	42	2.4	57	12.6	3,999	297
927.02	3	37	3.0	45	12.5	2,324	282
All six	2.3	44	2.6	59	12.4	13,468	1,730
(b) City of Phoenix							
1147	1	43	3.5	38	7.4	750	438
1144	1	46	2.9	48	9.3	1,029	168
1148	1	51	3.0	62	9.0	816	262
1156	2	37	4.3	86	12.5	452	21
1127	1	43	3.2	57	11.5	1,336	221
1125.04	3	43	2.9	78	11.8	2,788	899
All six	1.5	44	3.3	64	10.3	7,171	2,009

SOURCE: COLE'S DIRECTORY, 1990
NOTES:
1. Wealth Rating is based on a 1 to 5 scale, 5 being the most wealthy and 1 being the least.
2. H.H. is Household

tance (PCD) in miles for locating a new SWM facility. MPO was defined to be the square root of PCD [i.e., MPO = SQRT (PCD)].

3. Attitudes: four attitudinal questions regarding how people have felt or experienced the actual effects of an SWM facility, or how people believe or perceive the effects of a to-be-built facility.

4. Opinions: two opinion-type questions regarding people's preferences about size and dispersed location, and temporary versus permanent facilities.

The questions were asked rather than read as statements. It was determined during pretesting of the questionnaire that if an item is written as a statement and read to the respondent and the respondent is asked about the extent to which they agree or disagree, then the respondents' understanding seems to be slower and more error prone. As a result, the attitudinal responses were recorded as binary data (yes or no), but provisions were made for enthusiastic answers such as "strong yes" or "strong no" and for neutral "don't knows."

The response rates for the two surveys were moderate in various census tracts ranging from 20 percent to 47 percent. The average rates were 37.8 percent for the Glendale survey and 41.1 percent for the Phoenix survey. The Phoenix survey was conducted after the Glendale survey. As a result, higher response rates for the Phoenix survey may partly be attributed to interviewer's learning curve and partly to familiarity of local people with the Phoenix project.

The fourteen survey variables that were defined for the purposes of model fitting and data analysis are listed in Table 2. Since the surveys included four questions about negative impacts (ACC, PVAL, QLIFE, and MOVE), three new variables were created by aggregating three of them (PVAL, QLIFE, and MOVE) in various combinations. These "potential opposition measures" (POMs) were created to ascertain a multifaceted attitude toward transfer stations as a function of distance. POM1 represents addition of all three variables together; POM2 represents addition of PVAL and QLIFE; and POM3 represents addition of QLIFE and MOVE. These three variables have multiple ordinal values ranging from 0 to 3, where 0 means no negative attitudes toward an SWM facility, 1 means one negative response, and so on. The variable RDIST was used as an independent variable in the model fitting process. This variable represented survey respondent's rectangular distance from the facility. The rectangular metric was selected for the RDIST variable to emulate the grid street network of Phoenix and Glendale.

The response to the first question—previous knowledge of the facility—was used to divide the respondents into two groups. If the response is yes, answers to the attitudinal questions can be taken as attitudes based on some experience with the SWM facility. On the other hand, if the response is no, answers can be taken as attitudes based mostly on perceptions about an SWM facility. In this paper, the complete set of respondents is designated ALL, whereas those with previous knowledge are called HB (heard before) respondents, and those without previous knowledge are called NHB (never heard before) respondents. These two data sets further facilitated the investigation of the distance decay effect on two population subgroups, classified based on awareness.

TABLE 2 Survey Variables

Variable Name	Description
CT	Census tract
SEX	Gender of survey respondent
AWARE	1 if respondent is aware of the facility, 0 otherwise
ACC	1 for a 'yes' response to the question whether traffic accidents will increase due to a transfer facility; 0 for a 'no'
PVAL	1 for a 'yes' response to the question whether property value will go down due to a transfer facility; 0 for a 'no'
QLIFE	1 for a 'yes' response to the question whether quality of life will go down, 0 for a 'no'
MOVE	1 for a 'yes' response to the question whether one would like to move away due to the facility; 0 for a 'no'
DISPERSE	1 for a 'yes' response favoring dispersed small facilities over a single large one; 0 for a 'no'
TEMP	1 for a 'yes' response favoring the concept of having a temporary or periodic or portable facility; 0 for a 'no' response or favoring a permanent facility
PCDIM	Perceived comfortable distance in miles
POM1	Potential opposition measure 1 defined by aggregating the attitudinal responses to PVAL, QLIFE, and MOVE
POM2	Potential opposition measure 2 defined by aggregating the attitudinal responses to PVAL and QLIFE
POM3	Potential opposition measure 3 defined by aggregating the attitudinal responses to QLIFE and MOVE
RDIST	Rectangular or Manhattan distance of survey respondent from the facility site

METHODOLOGY

Because the response variables were binary (0-1) and the POM variables were integer, logistic regression methods available in the SAS (*10*) statistical software was used. In logistic regression, a discrete variable is converted into a continuous variable by using a cumulative probability function. For example, the discrete response to the property value impact question is converted into a continuous response by taking the probability of getting a positive response. Thus, the main objective in logistic regression is to find an appropriate functional form to estimate this probability. The probability function of a logit model is called the logistic function. In logit models, the dependent variable is the log odds ratio that a particular event will occur given specific values of the explanatory variable.

The logistic function is written as

$$E(Y = 1|x) = p = \exp\{g(x)\}/[1 + \exp\{g(x)\}] \quad (1)$$

where

$E(Y = 1|x)$ = probability (p) that $Y = 1$, that is, the probability of getting a positive response given the value of independent variable x; and $g(x)$ = logit transformation or link function.

The logit link function is written as

$$g(x) = b_0 + b_1 * x = \ln[p/1 - p] \quad (2)$$

where

ln = natural logarithm,
b_0 = constant coefficient, and
b_1 = slope coefficient of the independent variable.

In this research, several binomial and multinomial logit models were estimated for various dichotomous and polytomous response variables used in the attitudinal surveys. For most of the models reported here, appropriate logistic functions were used to determine probabilities of getting a positive response to the attitudinal questions.

Once a particular logistic regression model is fitted using the maximum likelihood estimation (MLE) method, the next step in analysis is to assess the significance of the independent variable in the model. This step is performed by checking the p-values of two criteria: the 2 log likelihood, and the score test. These two criteria give statistics and tests for the effects of the independent variable in the model (*11*). In this paper, distance from the facility (RDIST) is the only independent variable considered.

DATA LIMITATIONS

The listing-based sampling usually generates noncoverage bias caused by unlisted numbers or households without telephones. This research assumed that noncoverage bias in the surveys would not significantly alter the results.

The survey questionnaires did not include any socioeconomic type questions for several reasons. First, the main objective of the survey was to complement the facility location modeling process by exploring empirically the nature of a distance decay function representing people's opposition. Second, the surveys were not intended to explore relationships of NIMBY attitudes with demographic variables. Finally, the surveys were not intended to compare the Phoenix with the Glendale case. As such, inclusion of demographic variables in the surveys was not viewed as very critical. However, for interested readers, general demographic data on the two study areas have been provided in Table 1.

The sample sizes of the Glendale and Phoenix surveys provided estimates on population proportions with certain attitudes within an accuracy range of plus or minus 6 percent at 95 percent confidence level. However, two estimates had a higher error range of plus or minus 10 percent because of lower response rates for two specific questions. These two estimates are (a) population proportion in Glendale favoring dispersed small-sized transfer facilities and (b) perceived comfortable distance in Phoenix. These accuracy ranges are based on all surveys responding to a particular question. When the survey samples were divided into HB and NHB groups for regression analysis, the sample size for the HB group was considerably smaller than that for the NHB group. As a result, the HB data sets are treated separately from the NHB sets, then the error range increases to plus or minus 12 percent for the HB data sets and plus or minus 7 percent for NHB data sets at 95 percent confidence level. These error ranges were thought to be acceptable for this exploratory type research.

RESULTS

The Glendale Survey

The Glendale response profile is give in Table 3. Note that 78 percent of the respondents never heard about the facility before, and only 22 percent of the respondents were aware

TABLE 3 Response Summary of Glendale Survey

Survey Questions	Percent of Respondents[a]						
	by Census Tract						
Response Categories [1]	926 [2]	928 [3]	923.02 [4]	925 [5]	923.01 [6]	927.02 [7]	All [8]
When did you first hear about the facility?	(85)[a]	(54)[a]	(81)[a]	(23)[a]	(24)[a]	(26)[a]	(293)[a]
Today	68	82	83	91	79	77	78
Heard Before	32	18	17	9	21	23	22
How far in miles would it have to be to feel comfortable?	(85)[a]	(54)[a]	(82)[a]	(23)[a]	(24)[a]	(26)[a]	(294)[a]
0< mi <=3	28	14	16	13	13	16	19
3< mi <=10	35	59	43	48	34	50	44
mi >10	33	25	39	31	45	34	34
Don't Know	4	2	2	8	8	0	3
Do you believe that traffic accidents will increase?	(85)[a]	(54)[a]	(82)[a]	(22)[a]	(24)[a]	(26)[a]	(293)[a]
Yes	17	11	12	23	17	23	15
No	78	85	78	73	62	65	77
Don't Know	5	4	10	4	21	12	8
Is it likely that property values will decrease?	(85)[a]	(54)[a]	(82)[a]	(22)[a]	(24)[a]	(26)[a]	(293)[a]
Yes	47	52	51	50	63	54	51
No	50	46	34	50	17	39	41
Don't Know	3	2	15	0	20	7	8
Do you think quality of life will go down?	(85)[a]	(54)[a]	(78)[a]	(22)[a]	(24)[a]	(26)[a]	(289)[a]
Yes	12	13	5	14	17	8	11
No	83	87	94	77	83	92	87
Don't Know	5	0	1	9	0	0	3
Want to move away?	(85)[a]	(54)[a]	(82)[a]	(22)[a]	(24)[a]	(26)[a]	(293)[a]
Yes	8	15	9	27	13	8	12
No	86	85	89	73	87	92	87
Don't Know	6	0	2	0	0	0	2
Do you favor small dispersed facilities or single large?	(33)[a]	(38)[a]	(2)[a](5)[a]	(16)[a]	(21)[a]	(115)[a]	
Dispersed Small	55	79	50	80	31	29	56
Single Large	24	8	50	20	38	38	23
Don't Know	21	13	0	0	31	33	21
Are you in favor of temporary type facility or permanent?	(85)[a]	(54)[a]	(82)[a]	(22)[a]	(24)[a]	(25)[a]	(292)[a]
Temporary	50	63	47	36	12	20	45
Permanent	23	26	25	50	71	64	34
Don't Know	27	11	28	14	17	16	21

[a] Numbers in parentheses are respective sample sizes.

of the facility. Most Glendale respondents chose a range of 5 to 10 mi for their perceived comfortable distance from an SWM facility. When asked whether traffic accidents will increase because of a transfer station, almost 77 percent of the respondents said no and only 15 percent said yes. On the contrary, when asked whether property values will go down due to a transfer facility, 51 percent said yes and 41 percent said no. For the quality-of-life and move-away questions, a clear majority (87 percent) said no, indicating no perception of stress or threat to their quality of life in the community because of an SWM facility. Glendale respondents preferred the idea of having temporary or periodic SWM facilities over permanent facilities by a 45 percent to 34 percent margin. Again, 56 percent of respondents were concerned about size of the facility and were in favor of small-size facilities dispersed in many communities. Only 23 percent were in favor of a single large facility.

The regression analysis produced a number of significant models. These distance-based logit models, estimated from the Glendale attitude data, are presented in Table 4. The table also presents the p-values of the two criteria of model goodness-of-fit, and the p-value of the slope parameter estimate of the regressor variable RDIST. Low p-value (less than 0.05) for the parameter estimate indicates that the estimate is significant. Low p-values for the -2 log likelihood and the score statistic indicate that the effect of RDIST in the model is significant.

The first two models presented in Table 4 correspond to the response variable PVAL and describe the probability that respondents will show concern regarding the impact of property value given information about the distance of their homes from the existing location of the Glendale transfer facility. The first model was estimated using the data set HB, and the second model was estimated using the data set ALL. Note that the first PVAL model has a larger slope coefficient (0.2833 vs. 0.1336), which indicates that distance causes a higher rate of change in the property value attitude for the HB group. Observe that in both models, the estimated slope coefficient has a positive sign. The positive sign of association indicates that as distance from the transfer facility increases, so do the people's concern about the impact on property value. This association is an interesting finding because typically one would expect to see a negative association between distance and the impact on property value. A possible explanation for this unanticipated result is that most of the survey respondents who live close to the transfer facility either live in mobile trailer home parks or in low property-value areas and thus showed little concern about the property-value impact. In contrast, survey respondents who are far away from the facility live in relatively high property-value areas and logically showed more fear or concern about the property-value impact associated with a transfer facility. This fact provides one explanation for positive association between the two variables PVAL and RDIST, but there may also be other reasons that could not be identified with the survey.

The models for response variable ACC (increased traffic accidents) presented in Table 4 have negative signs on the slope coefficients, indicating a negative association between ACC and RDIST. The negative sign indicates that as the distance from the facility increases, the odds decrease of expressing concern about the impact of accidents. This model along with other distance-decay models estimated from the Glendale survey data are plotted in Figure 1. It is evident that

TABLE 4 Logit Models Estimated from Glendale Data

No	Survey Response Variable	Data Set	Estimated Regression Model	p-value of -2 Log L[a]	p-value of Score[a]	p-value of slope Estimate[b]
			(a) Binomial Logit Models[g]			
1	PVAL	HB[c]	ln [p/1-p] = 0.2833 x RDIST	0.0401	0.0432	0.0498
2	PVAL	ALL[e]	ln [p/1-p] = 0.1336 x RDIST	0.0359	0.0364	0.0376
3	ACC	HB[c]	ln [p/1-p] = -0.4236 x RDIST	0.005	0.0065	0.0102
4	ACC	NHB[d]	ln [p/1-p] = -0.9489 x RDIST	0.0001	0.0001	0.0001
5	AWARE	ALL[e]	ln [p/1-p] = -0.6305 x RDIST	0.0001	0.0001	0.0001
6	QLIFE	HB[c]	ln [p/1-p] = -0.9646 x RDIST	0.0001	0.0001	0.0001
7	QLIFE	NHB[d]	ln [p/1-p] = -1.416 x RDIST	0.0001	0.0001	0.0001
8	MOVE	HB[c]	ln [p/1-p] = -0.8623 x RDIST	0.0001	0.0001	0.0002
9	MOVE	NHB[d]	ln [p/1-p] = -1.1842 x RDIST	0.0001	0.0001	0.0001

[a] Criteria for assessing model goodness-of-fit.
[b] Maximum likelihood estimate of the slope parameter of the logit link function
[c] HB stands for 'Heard Before' referring to the data set which contains only those survey respondents who heard before about the transfer facility.
[d] NHB stands for 'Never Heard Before' referring to the data set which contains only those survey respondents who never heard before about the transfer facility.
[e] ALL refers to the data set which contains all survey respondents.
[f] Intercept estimate p-value.
[g] Probability of a yes outcome is denoted by p.

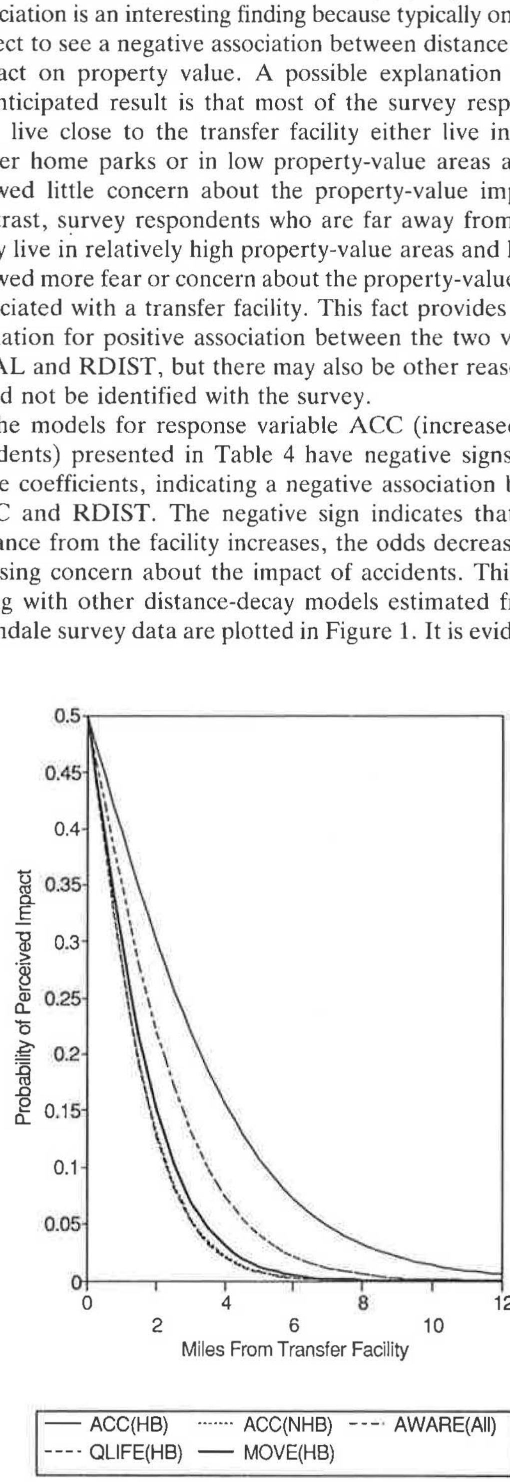

FIGURE 1 Distance-decay models estimated from Glendale survey.

the traffic accident impact to the HB group is mostly significant within 10 mi of the facility, whereas for the NHB group the impact is significant only within 4 mi. Beyond these distance estimates, the accident impacts are relatively constant and small.

The next hypothesis concerned how people's awareness about the facility (AWARE) varied by the distance (RDIST). The estimated binomial logit equation (presented in Table 4) shows that as distance increased, people's awareness seems to have dropped. The public awareness about the facility faded away beyond 6 mi from the facility.

The QLIFE and MOVE impacts are more significant for people who heard about the facility before than for those who never heard before. However, the impacts are not significant beyond 4 mi from the facility.

The Phoenix Survey

The Phoenix response profile is presented in Table 5. The majority (76 percent) of respondents never heard about the Phoenix southwest transfer facility project, and only 24 percent were aware of the project. These statistics on facility awareness are not radically different from those of Glendale. In contrast to Glendale, the Phoenix survey had a higher proportion of respondents who were in favor of a "single large" type facility, and only 18 percent were in favor of "dispersed small facilities." Also, in contrast to the Glendale survey, more Phoenix respondents favored the permanent type facility, and fewer liked the temporary concept. This difference in opinion structure between the two survey areas might partly be attributed to Phoenix respondents' bias toward the recent political decision by the City of Phoenix to have a single large facility. Other contributing factors may well be the differences in demographics between the two cities, which were not investigated in the surveys, or lack of understanding of the tradeoffs involved. The Phoenix responses to the attitudinal questions were similar to those of Glendale in the sense that most people singled out the property value impact as the most negative feeling associated with an SWM facility. Other factors, such as traffic accidents, quality of life, and relocation desire did not prove to be major concerns to the majority of respondents.

The Phoenix data were further investigated using logistic regression analysis to identify general associations between the survey attitudinal variables and RDIST. The logit models that were estimated from the Phoenix data are presented in Table 6. The plots of these equations are presented in Figure 2.

The first regression model presented in Table 6 describes log odds of PVAL as a function of the variable RDIST for the data set HB. Observe that the concern for the property value impact increases as distance from the facility increases. This relationship among the Phoenix survey respondents is similar to that among the Glendale survey respondents. The second PVAL model was estimated from the data set ALL and has a flatter slope compared with that of the first model.

The third and fourth regression models presented in Table 6 describe log odds of the relocation impact (MOVE) as functions of RDIST. The third model has a smaller negative slope coefficient than the fourth model, which implies that the prob-

TABLE 5 Response Summary of Phoenix Survey

Survey Questions / Response Categories [1]	Percent of Respondents[a] by Census Tract						
	1147 [2]	1144 [3]	1148 [4]	1156 [5]	1127 [6]	1125.04 [7]	All [8]
When did you first hear about the facility site?	(56)[a]	(46)[a]	(33)[a]	(31)[a]	(39)[a]	(48)[a]	(253)[a]
Today	82	67	85	74	80	71	76
Heard Before	18	33	15	26	20	29	24
Comfortable with the new site at 27th Ave & Lower Buckeye?	(56)[a]	(46)[a]	(33)[a]	(31)[a]	(39)[a]	(48)[a]	(253)[a]
Yes	70	67	61	55	51	58	61
No	30	33	39	45	49	42	39
How far in miles would it have to be to feel comfortable?	(17)[a]	(15)[a]	(13)[a]	(14)[a]	(19)[a]	(20)[a]	(98)[a]
0< mi <=3	0	0	0	7	0	0	1
3< mi <=10	18	27	8	36	10	0	15
mi >10	76	73	92	57	90	100	83
Don't Know	6	0	0	0	0	0	1
Do you believe that traffic accidents will increase?	(56)[a]	(45)[a]	(33)[a]	(31)[a]	(39)[a]	(48)[a]	(252)[a]
Yes	20	31	30	35	34	25	28
No	75	64	67	65	51	67	66
Don't Know	5	5	3	0	15	8	6
Is it likely that property values will decrease?	(56)[a]	(45)[a]	(33)[a]	(31)[a]	(39)[a]	(48)[a]	(252)[a]
Yes	52	73	55	61	59	56	59
No	36	20	36	32	29	42	33
Don't Know	12	7	9	7	12	2	8
Do you think quality of life will go down?	(56)[a]	(45)[a]	(33)[a]	(31)[a]	(39)[a]	(48)[a]	(252)[a]
Yes	9	16	12	7	13	19	13
No	87	84	88	90	82	81	85
Don't Know	4	0	0	3	5	0	2
Want to move away?	(56)[a]	(45)[a]	(33)[a]	(31)[a]	(39)[a]	(48)[a]	(252)[a]
Yes	9	2	3	10	10	10	7
No	89	96	94	90	87	88	91
Don't Know	2	2	3	0	3	2	2
Do you favor small dispersed facilities or single large?	(56)[a]	(45)[a]	(33)[a]	(31)[a]	(39)[a]	(48)[a]	(252)[a]
Dispersed Small	21	22	12	16	13	21	18
Single Large	45	47	58	48	46	46	48
Don't Know	34	31	30	36	41	33	34
Are you in favor of temporary type facility or permanent?	(56)[a]	(43)[a]	(33)[a]	(31)[a]	(39)[a]	(47)[a]	(249)[a]
Temporary	29	21	21	29	18	19	23
Permanent	45	63	61	51	61	58	56
Don't Know	26	16	18	20	21	23	21

[a] Numbers in parentheses are respective sample sizes.

TABLE 6 Logit Models Estimated from Phoenix Data

No	Survey Response Variable	Data Set	Estimated Regression Model	p-value of -2 Log L[a]	p-value of Score[a]	p-value of slope Estimate[b]
			(a) Binomial Logit Models[g]			
1	PVAL	HB[c]	ln [p/1-p] = 0.2583 x RDIST	0.0003	0.0006	0.0019
2	PVAL	ALL[e]	ln [p/1-p] = 0.11 x RDIST	0.0011	0.0013	0.0016
3	MOVE	HB[c]	ln [p/1-p] = -0.3655 x RDIST	0.0001	0.0001	0.0004
4	MOVE	ALL[e]	ln [p/1-p] = -0.7272 x RDIST	0.0001	0.0001	0.0001
5	AWARE	ALL[e]	ln [p/1-p] = -0.2506 x RDIST	0.0001	0.0001	0.0001
6	QLIFE	HB[c]	ln [p/1-p] = -0.2959 x RDIST	0.0001	0.0002	0.0008
7	QLIFE	NHB[d]	ln [p/1-p] = -0.2959 x RDIST	0.0001	0.0002	0.0008
			(b) Multinomial Logit Models			
8	POM1	HB[c]	$\ln [p_1/p_4] = -0.2564 \times RDIST$	0.0001	0.0001	0.0004
			$\ln [p_2/p_4] = 0.3746 - 0.2564 \times RDIST$			0.026[f]
			$\ln [p_3/p_4] = 2.163 - 0.2564 \times RDIST$			0.0001[f]

[a] Criteria for assessing model goodness-of-fit.
[b] Maximum likelihood estimate of the slope parameter of the logit link function
[c] HB stands for 'Heard Before' referring to the data set which contains only those survey respondents who heard before about the transfer facility.
[d] NHB stands for 'Never Heard Before' referring to the data set which contains only those survey respondents who never heard before about the transfer facility.
[e] ALL refers to the data set which contains all survey respondents.
[f] Intercept estimate p-value.
[g] Probability of a yes outcome is denoted by p.

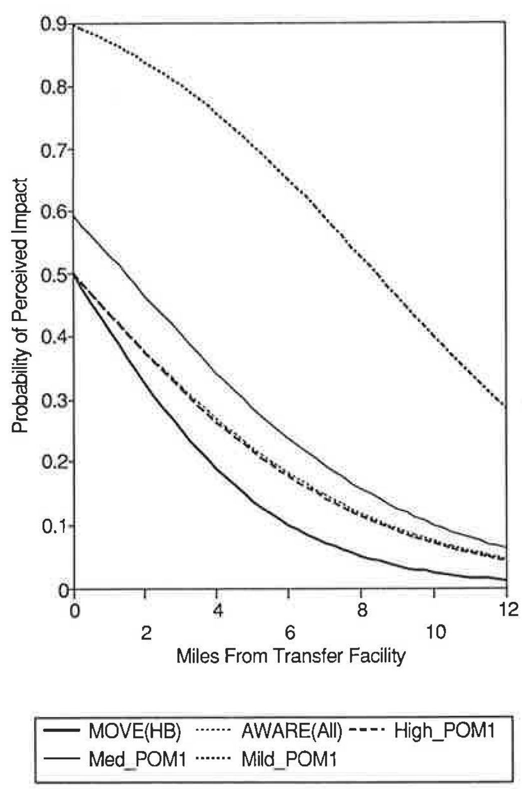

FIGURE 2 Distance-decay models estimated from Phoenix survey.

ability of relocation impact falls off more steeply with increasing distance among HB respondents than among NHB respondents. The probability of relocation impact is prominent within 10 mi of the facility for HB respondents, whereas it is only 5 mi for NHB respondents.

The fifth model presented in Table 6 shows how awareness about the Phoenix transfer facility project varied with the respondent's distance from the facility site. It is evident that the Phoenix facility had a longer range of awareness than the Glendale facility. This result was expected since the Phoenix transfer facility project has been well publicized in the community.

The sixth and seventh Phoenix models describe the log odds of the quality of life impact given the distance from the facility site. The two models are related to two groups of respondents: HB and NHB. The impact on HB respondents is greater than on NHB respondents, and both decrease exponentially with an increase in distance from the facility.

The last model presented in Table 6 is a multinomial logit model for the polytomous response variable POM1. The variable can have four possible values. Thus, three intercepts were estimated. Each equation in the model is called conditional logit and expresses the logarithm of odds of one outcome versus another as a linear function of the explanatory variable RDIST. Plots of these three conditional logit equations are presented in Figure 2. The curve labeled High_POM1 depicts the distance effect on the conditional probability of strong opposition (POM1 = 3); Medium_POM1 depicts the distance effect on medium opposition (POM1 = 2); and Mild_POM1 displays the distance effect on mild opposition (POM1 = 1). As expected, the strong opposition fades away sharply beyond 10 mi from the facility, whereas the medium opposition tends to be significant beyond 10 mi. Within 10 mi of the facility, the mild opposition is not likely to drop as sharply as that of strong or medium opposition. Other conditional logits can be derived algebraically from the given three logit equations. For example, $\ln(p_1/p_2) = \ln(p_1/p_4) - \ln(p_2/p_4)$.

CONCLUSIONS

This research explored empirically the spatial nature of perceived effects of siting solid waste management facilities in urban areas. The results of attitudinal surveys indicate that there are many negative perceptions toward SWM facilities, such as accident hazard and low quality of life and that these perceptions gradually decay over distance.

Both the Phoenix and Glendale surveys supported several hypotheses regarding attitude effects associated with SWM facilities. Several perceived or actual impacts of an SWM facility seem to be affected by people's distance from the facility. These distance effects were successfully modeled using several binomial and multinomial logit equations. Most of the survey variables (awareness, perceived threat of accidents, quality of life, and the combined potential opposition measure) showed statistically significant distance-decay. However, anomalous results were found showing perceived threat to property values increasing with distance, which might be discounted as a result of not controlling for socio-economic variation of various distances from the facility.

In a subsequent stage of this research (not reported here) the distance-decay equations were used for modeling the public opposition objective for the transfer facility location problem. These equations are an important contribution because this methodology can be used by SWM planners in locating facilities in such a way as to minimize perceived negative effects and, by assumption, opposition. These kinds of curves can be used directly in a location model, as in minimizing the systemwide average probability of perceiving any one of the impacts. Alternatively, they can be used indirectly by using them to empirically determine the perceived "impact radius" for a model that minimizes the number of people within the radius.

A majority of Glendale respondents expressed concern about the scale of a facility; they preferred the idea of having temporary SWM facilities dispersed in many communities. However, a majority of Phoenix respondents were in favor of a single, large-type permanent facility. It is suspected that this difference in opinion between the two survey areas can partly be attributed to Phoenix respondents' bias toward the recent political decision by the city of Phoenix to have a single large facility. Other contributing factors may well be the differences in demographics between the two cities, which were not investigated in the surveys. These results are interesting because they relate to the tradeoffs between cost and opposition that SWM facility planners must consider. Recently, Ratick and White (*8*), among others, have argued strongly that equity should be considered when planning for systems of undesirable facilities, where equity is considered to be a function of how many other places are also host sites for undesirable facilities. The survey results presented in this paper do not unequivocally support the notion that people prefer systems of a greater number of dispersed facilities, at least not for transfer stations. Further empirical research is needed to identify people's attitudes toward equity and risk sharing. Also, the ideas of political placation and welfare distribution by use of facility packages (*12*) are fruitful directions for future survey research.

This paper has been concerned primarily with statistical modeling of distance decay effects of siting an SWM facility. Therefore, it has made no attempt to discuss the many wider and complex issues that must be confronted in an actual siting process of a NIMBY facility.

REFERENCES

1. A. E. Radwan and D. K. Pijawka. The Economics of Transporting Solid Wastes. In *Transportation Research Record 1074*, TRB, National Research Council, Washington, D.C., 1986, pp. 25–31.
2. M. Rahman. *A Multiobjective Decision Model for a Transfer Facility Location Problem*. Ph.D. thesis. Arizona State University, Tempe, 1991.
3. E. Erkut and S. Neuman. Analytical Models for Locating Undesirable Facilities. *European Journal of Operational Research*, No. 40, 1989, pp. 275–291.
4. C. Zeiss and J. Atwater. Waste Facility Impacts on Residential Property Values. *Journal of Urban Planning and Development*, Vol. 115, No. 2, 1989, pp. 64–80.
5. C. Zeiss. Incinerator Impacts on Residential Property Sales: Beyond Price Effects. *Journal of Urban Planning and Development*, Vol. 116, No. 2, 1990, pp. 80–97.
6. C. Zeiss and J. Atwater. Property-Value Guarantees for Waste Facilities. *Journal of Urban Planning and Development*, Vol. 115, No. 3, 1989, pp. 123–134.
7. A. H. Mushkatel, K. D. Pijawka, and M. Dantico. *Risk-Induced Social Impacts: The Effects of the Proposed Nuclear Waste Repository on Residents of the Las Vegas Metropolitan Area*. Report NWPO-SE-032-90. State of Nevada Agency for Nuclear Projects/ Nuclear Waste Project Office, 1990.
8. S. J. Ratick and A. L. White. A Risk Sharing Model for Locating Noxious Facilities. *Environment and Planning—B*, No. 15, 1988, pp. 165–179.
9. *Cole's Directory, 1990*. Cole Publications, Phoenix, Ariz., 1990.
10. *SAS Language and Procedures Usage, Version 6*, 1st ed. SAS Institute, Inc., Cary, N.C., 1989.
11. D. W. Hosmer, Jr., and S. Lemeshow. *Applied Logistic Regression*. John Wiley and Sons, Inc., New York, N.Y., 1989.
12. M. Austin, T. E. Smith, and J. Wolpert. The Implementation of Controversial Facility-Complex Programs. *Geographical Analysis*, No. 2, 1970, pp. 315–329.

Publication of this paper sponsored by Committee on Social and Economic Factors of Transportation.