Migration and Residential Location of Workers at Nuclear Power Plant Construction Sites

Forecasting Methodology

Prepared by S. Malhotra, D. Manninen

Pacific Northwest Laboratory
Operated by
Battelle Memorial Institute

Prepared for
**U.S. Nuclear Regulatory
Commission**

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Prepared by
S. Malhotra, D. Manninen

Pacific Northwest Laboratory
Richland, WA 99352

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ABSTRACT

The primary objective of this study was to improve the accuracy of socioeconomic impact assessments by providing an improved methodology for predicting the number of immigrating workers and their residential location patterns at future nuclear power plant construction projects. Procedures for estimating several other variables which have important implications with respect to socioeconomic impact assessment (i.e., relocation of dependents, intention to remain in the area, type of housing selected, marital status, and average family size) were also developed.

The analysis was based on worker survey data from 28 surveys which were conducted at 13 nuclear power plant construction sites. These survey data were examined to identify patterns of variation in variables of interest across sites as well as across various worker groups. In addition, considerable secondary data reflecting various regional and project characteristics were gathered for each site. These data were used to estimate the effects of factors underlying the observed variation in craft-specific migrant proportions and the residential location patterns of immigrating workers across sites and surveys. The results of these analyses were then used as a basis for the specification of the forecasting procedures.

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INTRODUCTION

The purpose of this project was to enhance the accuracy of socio-economic impact assessments of large construction projects by providing an improved methodology for predicting the number of immigrating workers and their residential location patterns (SEAFORM).¹ This was accomplished by conducting a study of labor force migration and residential choice of workers at nuclear power plant construction sites. Specifically, in this study we developed methods by which information regarding local labor availability prior to plant construction, anticipated construction worker requirements, and various regional characteristics could be used to predict:

- the number of workers who will move to the area to work at the construction sites; and
- the residential location pattern of the immigrating workers.

In addition, an attempt was made to develop guidelines for predicting:

- the intention of these workers to remain in the area;
- the number of workers who will relocate their families;
- the type of housing that these workers will select; and
- marital status and average family size of the immigrating workers.

The initial phase of the study involved an extensive data collection effort. The survey data which were used in this study include the responses of over 49,000 workers from 28 surveys conducted at 13 nuclear power plant construction sites. These data were obtained in two different ways. Worker surveys were conducted at four nuclear power plant construction sites specifically for this study. In addition, we were able to increase the number of sites in our analysis by including data from similar surveys which were conducted by utilities at nine additional sites.

Considerable secondary data were also collected for this study. These secondary data include projected craft-specific labor requirements,

¹Despite the limited scope of our study, in keeping with the practice of other attempts to develop impact assessment models, we use the acronym **SEAFORM** to describe our socioeconomic impact assessment forecasting methodology.

as well as numerous regional and project characteristics, for each of the sites in the study. These data were obtained from a number of sources, including utilities and contractors, collective bargaining agreements, state agencies, census publications, and various other published sources.

In the analysis phase of the study, three separate analyses were performed. These analyses include:

- profile analysis;
- multivariate analysis; and
- development of forecasting procedures.

The specific purpose of the profile analysis was to examine construction worker survey data in a systematic fashion in an attempt to identify patterns of variation across sites and across various groups of workers at the same site with respect to a number of variables critical to estimating socioeconomic impacts. These variables include:

- (1) migrant proportion;
- (2) intention of movers to remain in the area;
- (3) relocation of dependents;
- (4) residential location patterns;
- (5) type of housing selected; and
- (6) demographic characteristics of movers.

The results of this analysis served several purposes. First, the results of the analysis were useful for (1) confirming the extent to which the evidence of similarity in variable profiles across sites justifies the practice of asserting similar impacts of construction in one area on the basis of case studies conducted in other areas; and (2) providing typical values of profile variables which might be useful in evaluating the accuracy of socioeconomic impact assessments. In addition, the profile analysis results were useful in formulating the multivariate analysis and in the development of forecasting procedures.²

²A complete discussion of the profile analysis portion of this study is contained in an appendix which, because of its length, is presented as a separate volume--Volume 11--to this report. The appendix volume entitled "Profile Analysis of Worker Surveys" is self-contained and can be read independently of this report.

The multivariate analysis was conducted in an attempt to explain the observed variation in migrant proportions and residential location patterns of movers across the sites and surveys included in our study. In particular, this analysis involved identifying the factors that influence workers' relocation decisions, defining variables to measure these factors, and isolating from among these variables, those which best explain the observed variation in migrant proportions and residential location patterns across sites.

Logit regression techniques were used to explain the observed variation in migrant proportions among various craft groups as a function of the following factors: (1) income potential associated with employment at the site; (2) craft-specific labor force requirements; (3) local availability of labor; (4) competing demand for labor in the region; (5) regional characteristics; and (6) various control variables. Similarly, a modified gravity model was used to explain the residential location patterns of movers. The gravity model was modified to allow the distance exponent to vary across sites and surveys. This was done by specifying the distance exponent as a function of factors such as differences in workforce composition, housing availability and other measures of the attractiveness of the local area.

The results of the profile and multivariate analyses were then used as a basis for the development of forecasting procedures. Procedures for predicting the extent of worker immigration and the residential location pattern of immigrating workers at future nuclear power plant construction sites were developed based upon the equations which were estimated in the multivariate portion of our analysis. Guidelines for estimating several other important factors which are critical to socioeconomic impact assessment (i.e., relocation of dependents, intention to remain in the area, type of housing selected, marital status, average family size) were also developed based upon our profile analysis results.

This report presents a detailed description of these forecasting procedures, as well as a summary of the analyses which led to their development. Whenever possible, background information and technical details are contained in appendices. The main body of the text is divided into 4 chapters. Chapter I presents a brief discussion of the data used in this study. The profile analysis and multivariate analysis

results are summarized in Chapters II and III. The final chapter presents a detailed description of the forecasting procedures. The major results of this study are summarized in the following section entitled "Conclusions."

CONCLUSIONS

Improved procedures for predicting the number of workers who will move to an area to work at a future nuclear power plant construction site, as well as the residential distribution of these immigrating workers in communities surrounding the site were developed in this study. These forecasting procedures were based upon the migration and residential location patterns of workers at ten nuclear power plant construction sites. The performance of the forecasting procedures was tested on the sites in our sample and the procedures were found to perform remarkably well. The mean absolute deviation between actual and predicted values of overall migrant proportions was only 2.9 percentage points and the root-mean-square deviation was only 3.7 percentage points. Similarly, the mean absolute deviation between predicted and actual proportions of movers living at 5-mile distance intervals of the site exceeded 5 percentage points in the case of only 2 of the 9 distance bands.

In addition to the procedures for predicting migrant proportions and residential location patterns at future nuclear power plant construction sites, procedures were also developed for predicting the intention of workers to remain in the area, the number of movers who relocate their families, the type of housing that workers will select, and the marital status and average family size of immigrating workers. The application of the proposed procedures in estimating the socioeconomic impacts associated with future construction projects can be expected to provide greater accuracy than was previously possible.

In the process of developing these procedures a much better understanding of the factors underlying the variation in key variables of interest in socioeconomic impact assessments was achieved. Some of the major findings in this regard were:

1. Workforce composition (the number of workers from various nonconstruction and construction crafts) during construction is an extremely important determinant of overall migrant proportions and residential location patterns at a site. For example, construction workers have lower migrant proportions than nonconstruction workers and in general also locate closer to the site. Furthermore, among construction workers

those workers who are more skilled (and therefore are relatively more scarce) have higher migrant proportions and these movers typically live closer to the site than other construction workers. Since workforce composition varies across sites as well as at the same site by stage of project completion, it becomes an important feature to consider in making socioeconomic impact assessments.

2. The nature of employment opportunities at a construction site differs for different construction craft groups. Some more specialized crafts are required for short periods of time, whereas other less skilled crafts are required throughout the entire construction period. Differences in the income potential associated with a particular move are a result of differences in labor requirements. The expected duration and continuity of employment and the expected growth pattern of employment opportunities at the site vary considerably across crafts. These variables were found to be an important source of the observed variation in craft-specific migrant proportions across sites.

3. The competing demand for labor at other power plant construction projects in the region (within 50 miles of the construction site) and the distance from the hiring hall of the union local with jurisdiction over the project provide reasonably good proxy measures for the demand and supply of labor in the area. Migrant proportions increase with higher utilization of labor and with longer distances from union halls. These proxy measures of labor availability are easily obtained and, therefore, can be considered in forecasting of migrant proportions at future construction sites.

4. Housing availability and regional population were shown to be key considerations in both the decision of workers to move to an area and their residential location decisions. Larger populations and greater housing availability are sources of attraction to potential workers. The influence of more rural surroundings is to increase the commuting distance of workers at the site. Migrant proportions decline because many workers choose to commute longer distances rather than move, and those who do move to work at the site choose to live farther from their place of work.

This study also made some important methodological contributions to socioeconomic impact assessment. It suggested ways in which data from a

limited number of sites could be used to conduct statistically valid analyses to evaluate key variables in socioeconomic impact assessments. In our migrant proportion analysis, we showed that using major construction crafts as the unit of analysis provided not only greater degrees of freedom but was also theoretically superior for analyzing the aggregate behavior of construction workers at a site. Such an approach allows one to use observed differences in migrant proportions among various worker groups to explain the overall migrant proportions at a construction site. In our residential location analysis we adopted a gravity model which was modified to allow differences in regional and project characteristics to influence the distance exponent of the model. As a result, the model is capable of yielding differences in residential location patterns which reflect a number of factors other than the population and distance of communities from the construction site.

However, despite the fact that the forecasting procedures described in this report were developed based upon a large number of nuclear power plant construction sites, their generalizability extends only to those future nuclear power plant sites whose major characteristics are similar to the characteristics of sites included in our sample. Nevertheless, the large number of sites, and the variation in a number of critical dimensions among the sites included in our study, serve to make the results of our analysis generalizable to a large number of future construction sites. If the characteristics of the future sites are very different from those of the sites in our sample (i.e., very remote), then the proposed forecasting procedures would not be appropriate. However, the methods which were used in this analysis will still be of value in such cases. New equations can be estimated which include sites with appropriate characteristics, and these results used to specify the desired forecasting procedures.

CHAPTER I

DATA

Fundamental to a study of this nature is the collection of a vast amount of information. Indeed, the preliminary step in this project involved an enormous data collection effort--the collection of primary as well as secondary data. This represents the largest and most comprehensive data set ever assembled for nuclear power plant construction projects. This chapter briefly describes the data collection effort. The chapter is divided into 2 sections. The first section introduces the primary and secondary data sources and the second section briefly discusses the quality and generalizability of the data. A more detailed discussion of the data collection effort is presented in Appendix A.

DATA SOURCES

The data set which was assembled for this study consists of information on over 49,000 workers from 28 surveys conducted at 13 different nuclear power plant construction sites. In addition to the survey data we collected a considerable amount of secondary data regarding the nuclear power plant projects and the surrounding regions.

Survey Data

The survey data included in the study were obtained in two different ways. Worker surveys were conducted at four nuclear power plant construction sites **specifically for this study.**¹ Cost considerations

¹**Conducting** a construction worker survey is not an easy task. This difficulty stems from the very nature of the construction site and the characteristics of the construction workforce. We successfully conducted worker surveys at four nuclear power plant construction sites. Our success in implementing these surveys can, to a large extent, be attributed to careful preparation for the survey activity and attention to detail in survey **administration.** The task required an extensive use of time and resources and **was** a valuable learning experience. For this reason we felt that it might be helpful to share our experience with others. Appendix 8, entitled "Construction Worker Surveys: A Means for Successful Implementation" systematically addresses the problems associated with conducting construction worker surveys and suggests possible methods to solve these problems. This document may be useful to others conducting worker surveys at large construction projects.

did not permit us to survey workers at more than four sites. However, we were able to increase the number of sites in our analysis by including data from similar surveys which were conducted by utilities at nine additional sites.

We exercised extreme caution in selecting the surveys to be included in our data set. Only surveys which we regarded as acceptable with respect to certain criteria were included in the study. These criteria were:

- (1) all workers at the site were surveyed;
- (2) the survey instrument was appropriate for analyzing variables of interest to our study; and
- (3) the sampling procedures and response rates of the surveys met certain minimum standards.

Since the surveys were conducted by several research groups using different survey instruments, the data collected were not identical for all sites. However, there was sufficient similarity in the information gathered in these surveys to address the major questions of this study. In general, workers were asked to provide the following information:

- a migrant status (i.e., whether or not the worker moved to the area to work at the construction site);
- a whether or not a mover relocated his family;
- a the intention to remain in the area after completion of the project;
- residential location;
- type of housing selected;
- a occupation; and
- various demographic characteristics (i.e., age, marital status, number of children).

Further details regarding survey administration, the nature of the data collected, survey instruments used and the characteristics of the sites at which the surveys were conducted are contained in Appendix A.

Secondary Data

Considerable secondary data were required for the multivariate analysis portion of this study. An extensive data collection effort was conducted in an attempt to obtain variables which would reflect the many factors underlying the observed variation in migrant proportions and residential location patterns across sites and across various craft

groups. In particular, secondary data sources were used to provide variables which reflect the following factors:

- income potential associated with employment at the site for various craft groups;
- craft-specific labor force requirements;
- availability of labor in the region;
- competing demand for labor in the region;
- population and housing availability in the region; and
- other regional and community characteristics.

These data were obtained from a number of different sources including collective bargaining agreements, utilities and contractors, state agencies, and various published sources. The problems encountered in the collection of the secondary data, the precise data items collected and the various data sources are described in Appendix A.

QUALITY AND GENERALIZABILITY OF THE DATA

There are several features of the data set which reflect the high quality of the data, support the generalizability of our results and increase the usefulness of this data set for other studies. These include the following: response rates achieved, amount of information contained in the survey data, and the extent of variation in relevant regional and project characteristics. Each of these features is highlighted briefly below.

Response Rates

In each of the 28 surveys, an attempt was made to survey all workers at each site at the time of the survey. The response rates ranged from a high of 94.9 percent to a low of 60.2 percent, with an overall response rate of approximately 81.5 percent. In general, these response rates were considerably higher than the response rates which are typically achieved in construction worker surveys. The high response rates of these census surveys considerably increases the confidence that can be placed in the results of our analyses based on these data.

Extensiveness of the Data

The data set is also rich in the sense that the surveys contain considerable **information** on worker characteristics and worker decisions.

The information contained in all 28 surveys was sufficient to allow us to address questions **regarding**²:

- the proportion of workers at a site who moved to the area to work at the site;
- the type of housing in which the movers live;
- the residential location patterns of both movers and nonmovers; and
- the household composition (**i.e.**, average family size and number of school-age children) of immigrating workers.

Considerably more information was available for some sites, which allowed us to address a number of other issues. These issues include:

- the intention of movers to remain in the area;
- whether or not movers maintain a permanent residence elsewhere;
- relocation of dependents; and
- demographic characteristics of nonmovers as well as movers.

Variation in Regional and Project Characteristics

Finally, these 13 sites and 28 surveys exhibit a wide range of variation in a number of important dimensions. For example, considerable variation can be observed with respect to regional distribution, the existence of other power plant construction activity in the region, local community characteristics, stage of project completion, utility and contractor arrangements, extent of unionization, and various power plant characteristics. Consequently, the data can be expected to yield estimates of critical socioeconomic variables under a variety of situations. This increases the usefulness of such an analysis, since an examination of these data is more likely to yield results which are generalizable to a variety of future nuclear power plant siting situations.

In **summary**, the primary and secondary data collected for this study represent the largest and most comprehensive data set ever assembled for nuclear power plant construction projects. Such an extensive data base

²**However**, in the case of 4 surveys which were conducted at 3 different sites, occupational **information** was not defined in the same way as for the other 24 surveys. As a result, it was necessary to exclude these surveys from all craft-specific analyses in this study.

could be extremely valuable in addressing a number of questions regarding socioeconomic impacts and nuclear power plant siting. In this study the data were used to examine the labor force migration and residential location decisions of nuclear power plant construction workers and to develop a methodology for forecasting labor force migration patterns at future construction sites. However, the data base could also be used both in policy-oriented analyses and in the preparation of environmental impact statements.

CHAPTER II

PROFILE ANALYSIS - SUMMARY OF RESULTS

In the profile analysis portion of this study we conducted a detailed examination of the construction worker survey data in an attempt to identify patterns of variation across sites and across various groups of workers at the same site with respect to a number of variables critical to estimating socioeconomic impacts. A separate volume entitled "SEAFORM - Profile Analysis of Worker Surveys Conducted at Nuclear Power Plant Construction Sites" was prepared as an appendix to this report. This appendix is very extensive and contains a comprehensive presentation of the data and a more detailed discussion of the results presented here.

In this chapter we summarize the major findings of the profile analysis. In addition, we discuss how the insights yielded by this analysis were useful in the multivariate portion of our analysis, which was a critical step in our development of procedures for forecasting migrant proportions and residential location patterns of movers at future power plant construction sites. The results of this analysis also suggested means by which one could make improved predictions regarding the relocation of dependents, intention to remain in the area, type of housing selected and demographic characteristics of movers.

This chapter is divided into 3 sections. The first section describes the major focus of the profile analysis. The second section presents a brief summary of results. The final section discusses the implications of the findings for our multivariate analysis and for the development of forecasting procedures.

FOCUS OF THE PROFILE ANALYSIS

Differences in migrant proportions among various occupational groups have been observed in past studies.¹ However, no attempt has been made

¹For example, see Mountain West Research, Inc., Construction Worker Profile, Final Report (Washington, D.C.: Old West Regional Commission, 1975), p. 19.

to examine differences in variables such as migrant proportions, intention to remain in the area, relocation of dependents, residential location patterns, type of housing, and demographic characteristics of movers among various worker groups in any systematic way. The intent of this analysis was to determine the extent to which occupational groups exhibit differences with respect to variables which are critical to socioeconomic impact assessment and, therefore, to determine the extent to which workforce composition could be an important factor in understanding the observed variation in the variables of interest across sites.

The importance of considering workforce composition stems from the fact that both the demand for labor at the construction site and the availability of labor within commuting distance vary for different craft groups. For instance, crafts with more specialized skills are required for jobs of relatively limited duration, whereas other crafts are required throughout the entire construction phase. Moreover, other opportunities for employment in the area during and upon completion of the project vary considerably for different crafts. Since it is likely that these factors influence workers' relocation decisions, our analysis attempts to measure the extent to which differences in variables of interest are observed among various craft groups.

First, we divided workers into two broad occupational groups-- construction and nonconstruction workers.¹ Each of these groups was then further subdivided. In the case of the nonconstruction group, workers were divided into two subgroups. The first group included all managers, engineers and supervisors. The second group included the remaining nonconstruction workers (i.e., the clerical, security, and medical/nursing staff).

We further divided construction workers into three groups based on the relative scarcity of labor among the different construction crafts.³ This classification of crafts into scarcity groups was based on two

²Information on workers' crafts was not available for four of the surveys in our sample. Therefore, it was necessary to exclude these sites from our analysis of variation among various subgroups of workers.

³We first subdivided workers into eight major construction craft groups. However, the extensive variation in migrant proportions across craft groups made it extremely difficult to observe any consistent patterns of variation among groups without conducting a multivariate analysis.

factors: (1) the size of the craft labor markets, and (2) the demand for their services at nuclear power plant construction sites. We defined our proxy measure of relative scarcity of labor to be the ratio of the number of manhours of labor required in each craft to construct a typical nuclear power plant and the total number of union members in the construction craft in the nation.⁴

This ratio was used to classify all construction crafts except laborers and teamsters into two scarcity groups: a scarce craft group and a common craft group.⁵ Laborers and teamsters formed the third scarcity group--an abundant craft group. We treated laborers and teamsters differently from the other crafts because these jobs do not require very specialized skills. These occupations do not have lengthy apprenticeship programs, as is the case with other construction crafts. Therefore, it is relatively easy to meet an increase in the demand for laborers and teamsters by attracting workers from other occupations.

In addition to our examination with respect to various worker groups, we also examined possible variation in relevant variables with respect to region. Among the 13 sites included in our study, four were located in northern states and nine were located in southern states. We examined the data in an effort to determine the extent to which systematic differences exist between northern and southern sites.

Six factors were identified as critical for accurately determining the socioeconomic impacts associated with large construction projects. These factors, including definition of the variables used in the analysis, are as follows:

- Migrant proportion--the proportion of workers who moved to the area to work at the site. Workers were classified as movers and nonmovers in two ways, depending upon the survey instrument used. Some questionnaires asked workers whether or not they had

⁴We recognize that this measure of relative scarcity of labor is rather crude. Ideally, this measure should have been based upon regional estimates of the demand and supply of the various construction crafts. Unfortunately, data to develop such a scarcity measure were not available.

⁵The scarce craft group includes pipefitters, ironworkers, asbestos workers, and boilermakers. Carpenters, electricians, operating engineers, sheetmetal workers, bricklayers, and cement masons comprise the common group.

moved to the area to work at the site. Workers who responded "yes" to this question were considered to be movers. Other questionnaires asked for the worker's current address and their address before beginning work at the site. A comparison of these responses was used to classify workers as either movers or nonmovers.

- Intention to remain in the area--the proportion of movers who are temporary (movers who intend to leave the area before or upon completion of the project). Two different measures were defined to examine this factor. First, based upon workers' responses to a direct question regarding their intention to remain in the area, we classified movers as either permanent or temporary movers. Temporary movers were defined to be those movers who expected to leave the area either before or on completion of the project. Second, as an indirect measure, we examined the proportion of movers who maintain a permanent residence elsewhere as an indication of intention to leave the area upon completion of the project.
- Relocation of dependents--the proportion of movers with family present. In our analysis we examined movers with family present as a proportion of all movers, rather than a proportion of married movers. Thus, movers without families include single movers as well as married movers who did not relocate their families.
- Residential location--the proportion of movers and nonmovers living at various distances from the construction site. Two different variables were examined. First we examined the proportion of movers and nonmovers living in 5-mile intervals of the site. Second, we examined the proportion of movers and nonmovers living in the local impact area (i.e., within 15 miles of the site).
- Type of housing--the proportion of movers living in four different housing types. The four housing types which were examined include houses, mobile homes, apartments, and other temporary housing (i.e., hotels, motels, boarding and rooming houses).
- Demographic characteristics of movers--marital status, family size, number of school-age children and income.

SUMMARY OF RESULTS

The results of our analysis indicate that overall migrant proportions at a site typically range from 15 to 35 percent. More than half of all movers intend to leave the area before or upon completion of the construction project. Although these temporary movers are less likely to relocate their families, 50 to 70 percent of the workers who move into the area are likely to bring their families with them. In general,

.. movers live relatively close to the construction site. In fact, we found that 45 to 85 percent of the movers live in the local area (within 15 miles of the site) compared to only 10 to 25 percent of the nonmovers. Movers who relocate their families typically live farther away from the site, as do the permanent movers. Most movers and almost all movers with families choose to live in single family houses and mobile homes.

The characteristics of the movers did not vary much from site to site. About 75 to 85 percent of the movers are married. The average family size of those movers who relocate their families is 3.25, and the average number of school-age children among movers is 0.8. The family income of movers generally exceeds \$20,000 (1978 dollars).

We found significant differences when we examined profile variables by various worker groups. Forty to 60 percent of nonconstruction workers are movers, while only 10 to 30 percent of construction workers are movers. The difference is primarily due to management workers--60 to 75 percent of those workers are movers. Nonconstruction movers (60 to 75 percent) are more likely to leave the area by the time the project is completed than construction movers (40 to 50 percent). However, despite the more temporary nature of their move, nonconstruction workers are more likely to relocate their families than are construction workers. There is no difference in the residential location patterns of construction and nonconstruction movers, although construction movers are more likely to live in mobile homes and nonconstruction movers are more likely to live in single family houses.

Among construction workers, some salient differences were observed between workers from different crafts. We found that the migrant proportions typically range from 15 to 45 percent among workers from scarce crafts, but range from 10 to 30 percent among workers from common crafts and only 5 to 10 percent among workers from abundant crafts. The movers among the scarce craft group are more likely to leave the area before or upon completion of the project and are less likely to relocate their families. However, the location and type of housing chosen by movers from scarce crafts is not very different from that of movers from other craft groups.

Finally, we did observe some evidence of distinct differences in profile variables with respect to region. Overall migrant proportions at

the southern sites are somewhat higher than those at the northern sites. Also, significantly higher proportions of movers relocate their families in the South than do movers in the North. Although there is no apparent regional difference in the residential location patterns of movers, there is a significant difference in the type of housing chosen by movers in the two regions. A much higher proportion of movers live in mobile homes, and to a lesser extent in single family houses, in the South than in the North. Similarly, lower proportions of movers live in apartments, hotels, motels, and rooming houses in the South than in the North.

The above discussion has been a general overview of the major findings of our profile analysis. A more detailed summary of specific findings of the analysis of each profile variable is presented below.

1. Migrant Proportions

The major findings of our profile analysis of migrant proportions are as follows:

- There is a large variation across sites in terms of overall migrant proportions and in migrant proportions among various worker groups. Typically, overall migrant proportions range from 15 to 35 percent.
- Migrant proportions are higher among nonconstruction workers (40 to 60 percent) than among construction workers (10 to 30 percent).
 - a Higher migrant proportions among nonconstruction workers are due to management workers (60 to 75 percent) and not to clerical workers (20 to 35 percent).
- Relative scarcity of labor explains a considerable amount of variation among construction crafts. Migrant proportions among workers from scarce crafts (15 to 45 percent) are higher than those among workers from common crafts (10 to 30 percent), which in turn are higher than migrant proportions among workers from abundant crafts (5 to 10 percent).
 - a A significant difference in migrant proportion by region among various worker groups is found only in the case of **nonconstruction** workers. This regional difference reflects the difference in the migrant proportions among clerical workers. Migrant proportions among clerical workers in the North (10 to 20 percent) are lower than those in the South (25 to 30 percent).

2. Intention to Remain in the Area

The major findings of our profile analysis of the movers' intentions to remain in the area are as follows:

- Temporary movers constitute a significant proportion of the movers at a site. Typically, 50 to 60 percent of all movers expect to leave the area before or upon the completion of the construction project.
- a The proportion of movers who could be classified as temporary among nonconstruction workers (60 to 75 percent) is higher than that among construction workers (40 to 50 percent).
- Nonconstruction movers, despite the temporary nature of their employment, are less likely to maintain a permanent residence elsewhere than are construction movers. Thus, use of a permanent residence as an indication of intention to remain in the area is appropriate for construction workers but not for **nonconstruction** workers.

3. Relocation of Dependents

The major findings of our profile analysis of relocation of dependents are as follows;

- a There is a large variation across sites in terms of the proportions of all movers with family present and in the proportions among various worker groups.
- a Typically, overall proportions of movers with family present range from 50 to 70 percent. The overall proportions of movers with family present are higher among sites in the South than among sites in the North.
- a Region explains a considerable amount of variation in the proportions of movers with family present. In all cases proportions for various worker groups were higher in the South than in the North.
- Proportions of movers with family present are higher among **nonconstruction** movers (in the North from 60 to 75 percent and in the South from 70 to 85 percent) than among construction movers (in the North 45 to 55 percent and in the South from 50 to 70 percent).
- a In the North, proportions of movers with family present are lower among movers from scarce crafts (40 to 50 percent) than among movers from other crafts (50 to 55 percent). A similar difference between craft groups is not apparent among southern sites.
- a Among construction movers, **relocation** of dependents is **related** to movers' intentions to remain in the area. Among **nonconstruction** movers, the intended length of stay is not related to the proportion of movers with family present.

4. Residential Location

The major findings of our profile analysis of residential location are as follows:

- The residential location patterns of movers and nonmovers are different and they both exhibit considerable variation across sites. The variation stems from differences in the numbers and sizes of communities in the regions surrounding the sites.
- a Higher proportions of movers reside in communities closer to the site relative to the proportions of nonmovers residing in those communities. Typically, higher proportions of movers in relation to the proportion of nonmovers live in communities within 20 miles of the site and vice versa in communities beyond 20 miles from a site.
- a In the North nonmovers typically live much closer to the site than in the South, but there is no such regional difference in the residential location patterns of movers.
- Even in the most rural sites 70 percent of the movers live within 25 miles of the site.
- The overall proportions of movers living in the local area (45 to 85 percent) is significantly greater than the proportions of nonmovers living in the local area (10 to 25 percent).
- The proportions of movers living in the local area are similar for all worker groups.
- The presence or absence of a family and movers' intentions to remain in the area influence residential location decisions.

5. Type of Housing

The major findings of our profile analysis of type of housing are as follows:

- There is considerable variation in the type of housing selected by movers across sites. Generally, 60 to 90 percent of movers live in single family houses or mobile homes.
- Typical ranges of the proportions of movers living in each of the four housing types are as follows: single family houses--30 to 45 percent; mobile homes--20 to 45 percent; apartments--10 to 20 percent; and all other types of housing--less than 10 percent.
- There are significant differences in the type of housing selected by construction and nonconstruction movers:

- Lower proportions of construction movers (25 to 40 percent) live in single family houses than nonconstruction movers (50 to 65 percent);
 - Higher proportions of construction movers live in mobile homes (35 to 55 percent) than nonconstruction movers (10 to 25 percent);
 - Somewhat lower proportions of construction movers (5 to 20 percent) live in apartments than nonconstruction movers (10 to 25 percent);
 - Higher proportions of construction movers (5 to 20 percent) live in other types of temporary housing than nonconstruction movers (less than 10 percent).
- o There are significant regional differences in the type of housing selected by movers. Single family houses and mobile homes are more likely to be chosen (overall and by all worker groups) in the South than in the North. Correspondingly, apartments and other types of temporary housing are less likely to be chosen (overall and by all worker groups) in the South than in the North. Overall proportions living in different types of housing are:
--	Single family houses	North	35 to 40 percent
		South	40 to 50 percent
--	Mobile homes	North	About 20 percent
		South	35 to 50 percent
--	Apartments	North	25 to 35 percent
		South	10 to 20 percent
--	Other types of housing	North	10 to 15 percent
		South	0 to 5 percent
- o Presence or absence of a family is related to the type of housing selected by movers. Typically, higher proportions of movers with family present (45 to 65 percent) live in single family houses compared to movers without family present (10 to 20 percent). Few movers with family present live in hotels/motels, etc., but 10 to 25 percent of movers without family present live in such temporary quarters.

6. Demographic Characteristics of Movers

The major findings of our examination of the demographic characteristics of movers are as follows:

- Among construction movers, the proportion of movers who are married is higher in the South (85 percent) than in the North (75 percent). No regional difference, however, was apparent among the nonconstruction group.
- Average family size varied across worker groups. The average family size of construction movers (3.4) was somewhat higher than that of nonconstruction movers (3.1).

- Average number of school-age children also varied across worker groups. The average number of school-age children was .85 among construction movers, compared with only .6 among nonconstruction movers.
- The median family income of all movers was approximately \$21,000 a year (1978 dollars), with the average among the nonconstruction (\$21,700) group being higher than among the construction group (\$20,500). Similarly, the median family income among the scarce movers (\$21,000) was higher than than among the common and abundant mover group (\$19,300).

IMPLICATIONS FOR FORECASTING

The results of this profile analysis have demonstrated that there is a large variation in key variables (i.e., migrant proportions, relocation of dependents, residential location, type of housing selected) across sites and surveys. The results of the analysis have also shown systematic variation in these key variables across worker groups. These differences across various worker groups, however, are not surprising in light of the differences among worker groups with respect to the local availability of workers in the area immediately surrounding the construction site, the degree of specialization required in tasks performed, and the nature of labor requirements (potential for employment) at the site.

Consider, for example, the observed differences in key variables among construction crafts grouped by relative scarcity of labor. The lowest migrant proportions were observed among the abundant craft group (laborers and teamsters). These crafts do not require extensive prior training and their skills are not specific to any particular type of construction project. As a result, workers from these crafts are readily available locally and, as such, can be easily recruited from the local labor pool. There are, of course, other more specialized construction crafts, such as those represented in the scarce craft group, and the local labor supply is less likely to be able to provide a sufficient number of such workers. Therefore, it is not surprising to observe greater numbers of movers among crafts which are relatively scarce.

Differences in other profile variables, such as intention to remain in the area, relocation of dependents, and type of housing selected, also lie in differences in employment opportunities for various worker groups. The construction industry is characterized by a high labor turnover. Employment for construction workers is seldom permanent. Rather,

workers are hired for specific jobs of a limited duration. Especially among workers from the scarce craft group, it is often necessary for workers to move from site to site or to commute rather long distances each day to maintain steady employment. Opportunities for continued employment at the construction site, as well as in the area upon completion of the project, are fewer among the scarce craft group. Not surprisingly, we did observe that workers from the scarce crafts are more likely to leave the area either before or on completion of the project, are more likely to maintain a permanent residence elsewhere, are less likely to relocate their families, and are more likely to live in temporary housing near the construction site.⁶

Differences in the availability of labor in the area and the nature of employment opportunities at the construction site are also important factors underlying the extremely different migrant proportions of the management and clerical groups. Management workers are generally more educated and their jobs have relatively high salaries. These workers are not likely to be readily available in the area, especially in the case of more rural sites. Instead, many of these workers are regular employees of the utility or prime contractor and are moved to the area specifically to work on the project. Clerical workers, on the other hand, have jobs that require less education and training and, as a result, most of them are hired locally.

Similarly, with respect to other key variables, the behavior of non-construction movers is consistent with differences in the nature of employment opportunities. Since most nonconstruction movers consist of management rather than clerical workers, these workers typically are employees of the utility or the prime contractor and most likely will be transferred upon completion of the project. Furthermore, the long term employment potential for these workers in this area (especially a rural area) is rather limited. As a reflection of these factors, we did observe that most nonconstruction movers expect to leave the area upon

⁶Interestingly, workers from all worker groups who moved to the area to work at the construction site locate relatively near the site. Residential location was the only variable in which we did not observe any systematic variation among various groups of movers.

completion of the project. However, despite the temporary nature of their employment, most nonconstruction movers do relocate their families. A possible explanation for this is that although their tenure at the site is limited, it is not necessarily short. Employment at the site is quite stable and could extend for a period of up to ten years. In addition, the employment contracts of management workers are likely to cover the cost of moving their families. And, indeed, our analysis did show that, compared with construction movers, nonconstruction movers were much more likely to relocate their families and to live in more permanent, single family housing.

The findings of this profile analysis have important implications for the development of forecasting procedures. These implications include: (1) the need to conduct a multivariate analysis; (2) the importance of workforce composition in explaining the observed variation across sites and surveys; (3) the identification of explanatory variables; (4) justification for adopting a craft-specific approach to model development; and (5) other considerations. Each of these implications is discussed in greater detail below.

The Need to Conduct a Multivariate Analysis

Foremost, the results of this profile analysis indicated that there is a large variation in migrant proportions and residential location patterns across sites. This suggests that the practice of making forecasts at one site based solely upon the observed values at another site (or even the average across several sites) can be a dangerous practice. In addition, our examination clearly highlights the need for a multivariate analysis to improve our understanding of the factors underlying the variation in these variables across sites as a necessary first step in the development of improved forecasting procedures.

Another rather interesting finding is the very pronounced difference with respect to key variables which was observed between construction and nonconstruction workers. In most cases, however, this variation was seen to reflect basic differences in the nature of employment opportunities between the two groups at construction sites. This suggests that the factors underlying such relocation decisions are not the same for these two worker groups. The implication of this for purposes of model development is simply that a separate model should be developed for each

group. Combining these two very different groups in the same model is likely to result in a reduction in the overall predictive power of the model.

The Importance of Workforce Composition

The results of this analysis have clearly demonstrated a systematic variation in migrant proportions across worker groups. This implies that workforce composition could be a very important factor in explaining the variation in overall migrant proportion across sites. Table 1 presents the proportion of the total workforce in each of ten craft groups at the time of the survey for the 24 surveys for which information on craft was available. As can be seen in the table, workforce composition varies considerably from site to site and at the same site at different stages of project completion.⁷

Because migrant proportions vary considerably for different worker groups and because workforce composition varies across sites, the variation in overall migrant proportions may, to a large extent, reflect differences in workforce composition. Thus, any attempt to explain the observed variation in migrant proportion across sites should explicitly include a consideration of workforce composition at the site at the time of the survey.

The Identification of Explanatory Variables

These findings were also useful in identifying several factors underlying the observed variation in migrant proportions across sites and across various worker groups, and therefore were useful in defining variables to be included in the multivariate portion of our analysis. In particular the results of the analysis indicate that the availability of labor in the area and the nature of labor requirements could be important factors in explaining the observed variation in these variables across sites.

⁷Operating engineers, for example, ranged from 2.7 percent of the total workforce at one site to 29.7 percent at another. Similarly, pipefitters varied from 5.1 to 25.8 percent of the total workforce.

TABLE 1

Workforce Composition at Time of Survey by Craft Groups
(Proportion of Total Workforce)

Survey Identification Number	Pipefitters	Ironworkers	Boilermakers	Operating Engineers	Electricians	Carpenters	Other Construction	Labors	Clerical	Management
1.0	5.9	14.0	4.3	6.6	5.1	15.3	1.8	20.6	10.8	15.6
2.0	18.8	11.9	2.9	8.4	6.6	16.1	3.5	18.9	3.5	9.5
3.0	18.0	17.6	4.3	6.7	5.6	13.4	8.6	16.8	4.1	4.8
4.0	16.9	15.5	3.7	3.7	13.2	13.2	12.1	14.9	3.7	3.1
8.0	22.3	2.4	2.4	2.7	11.5	7.3	9.2	16.7	9.4	16.0
9.1	6.2	7.1	.2	18.0	8.9	11.7	5.6	22.2	7.8	12.5
9.2	10.3	12.2	2.9	5.1	9.1	20.3	4.7	10.6	7.0	17.8
9.3	11.0	3.4	3.1	3.9	13.8	23.1	7.3	17.1	5.1	12.0
9.4	14.8	12.1	5.6	5.7	13.0	15.5	6.3	13.8	3.8	9.4
10.1	11.4	8.1	2.8	6.0	8.9	24.6	6.6	19.6	4.1	7.8
10.2	25.8	6.8	4.3	8.0	10.6	12.8	7.2	14.4	4.0	6.0
10.3	17.6	5.4	2.8	9.3	16.5	12.4	5.8	14.5	5.4	10.3
11.1	5.5	12.5	.0	18.8	3.6	20.2	3.9	18.8	5.4	11.4
11.2	9.2	13.2	3.5	7.8	9.3	15.5	6.4	25.6	3.1	6.5
11.3	8.5	2.0	2.3	11.3	17.4	18.7	3.3	15.6	5.6	15.4
11.4	24.4	1.9	.0	4.7	18.5	8.7	8.7	11.8	2.9	18.5
12.1	5.1	1.5	.0	18.9	3.1	7.7	8.4	35.5	8.4	11.5
12.2	9.2	10.9	.2	10.0	5.1	20.4	1.3	24.3	6.5	12.2
12.3	13.3	8.8	1.4	6.1	11.1	19.2	5.8	17.0	4.8	12.5
12.4	21.4	6.3	2.0	6.3	17.5	10.5	7.8	14.4	3.7	10.2
13.1	8.1	7.9	.6	29.7	3.8	7.7	8.2	15.4	5.2	13.4
13.2	7.8	6.4	.1	25.5	6.8	7.9	6.5	22.5	5.2	11.2
13.3	9.7	11.1	1.3	23.5	5.3	8.4	4.7	16.8	5.8	13.3
13.4	9.7	12.5	1.8	18.8	5.2	9.2	4.2	17.9	5.7	15.0

The availability of labor varies considerably across craft groups as well as across sites, depending upon factors such as the **urban/rural** nature of the surrounding area. If there are several large cities within daily commuting distance of the site, one might not observe large numbers of workers moving to the area to work at the site. This may be particularly important among workers from the scarce crafts, whose availability may be somewhat limited in rural areas. The attractiveness of employment opportunities for various craft groups depends upon the nature of labor requirements. This includes a variety of factors such as the total number of workers required, and the expected duration and continuity of employment. There is considerable variation in these labor requirement variables both across sites and across crafts. Since it is these variables which determine the expected value of benefits associated with employment at a particular site, it is therefore likely that these variables will also influence workers' relocation decisions.

In addition, the large variation in migrant proportions across sites and surveys for the same group of workers suggests that there are site and project specific variables which might also be important in explaining the observed variation across sites and surveys. Thus, this analysis suggests that any model which is developed to explain the observed variation in migrant proportions should include variables which reflect various regional and project characteristics, as well as variables which reflect the availability of labor in the area and the relative attractiveness of employment opportunities at the construction project. However, these factors typically have not been considered in empirical studies of this nature.

Justification for Adopting a Craft-Specific Unit of Analysis

A very important finding of this analysis is that one observes considerable variation in key variables among different worker groups. This suggests that occupation may be an important dimension in examining these issues. The importance of this finding is that it allows one to perform a multivariate analysis using craft-specific worker groups as the unit of analysis.

Past studies of this nature have been limited by the availability of data. Construction worker survey data are difficult to obtain and, as a

result, data are not available for a large number of sites. Indeed, past studies have often been limited to at most 14 sites. If the site is used as the unit of analysis, the data do not provide a sufficient number of observations to conduct a multivariate analysis. However, the results of our examination indicate that it is possible to identify 7 or 8 major craft groups, with sufficient numbers of workers in each craft group, to examine variation with respect to each craft group at each site. Adopting this approach provides a sufficient number of observations for a multivariate analysis, thereby overcoming the data limitations which have hindered past studies of a similar nature.

An additional advantage of using craft as the unit of analysis stems from the fact that labor requirements are craft-specific. Thus, it will be possible to consider the importance of a number of craft-specific labor requirement variables such as income potential associated with employment at the site, labor requirements for project construction, local availability of labor and competing demand for labor for each craft group, in addition to the importance of regional and project characteristics, in explaining the observed variation across sites and crafts.

Other Considerations

Finally, examination of the data in early stages of the profile analysis allowed us to define more carefully the terms and definitions used in subsequent analyses. An examination of past studies indicated that a confusion in terminology has stemmed from a failure to distinguish between a change of residence and the impact area based on geographic proximity to the site.⁸

In our analyses we attempted to avoid this problem by classifying workers independently according to 2 different criteria--the first based on change of residence and the second based on geographical proximity to

⁸This confusion stems from the fact that different terms have been used by different groups to refer to the same phenomenon; and, similarly, the same term has been used to refer to entirely different concepts. For example, some past studies have used the term nonlocal worker to refer to workers who moved into the area to work at the site. Others have used the same term to refer to those workers who commute from outside the local impact area.

the site.⁹ In our residential location analysis we defined two impact areas--a regional impact area and a local impact area. The local impact area was defined as the area within 15 highway miles of the site. The regional impact area was defined as the area within a 50-mile radius of the site. These definitions were determined based upon our profile analysis results. A similar examination of the data aided in the definition of terms in our examination of other key variables.¹⁰

The terms and definitions which we adopted were an important output of our profile analysis. By identifying sources of confusion in terminology and by using the data to suggest more precise definitions of terms, we were able to conceptualize subsequent analyses more clearly. Furthermore, adopting precise definitions of terms commonly used in socioeconomic impact assessments is critical to achieving a consistent set of empirical results for purposes of improving forecasting procedures.

In conclusion, our examination of several key variables has identified considerable variation across sites and across different worker groups. These findings suggest the need for a multivariate analysis to explain the observed variation across crafts and sites as a possible means of improving forecasting procedures. Focusing upon the two most important variables--migrant proportions and residential location--we examined the observed variation within a multivariate analysis framework. The results of this analysis are presented in the following chapter. Resource limitations did not permit us to conduct a multivariate analysis of the other variables of interest. However, the

⁹In our examination of migrant proportions we classified worker as movers or nonmovers based upon change of residence. We defined movers to be those workers who changed residence to work at the construction site. Workers who did not change residence to work at the site were therefore classified as nonmovers. In our examination of residential location we classified workers as local or nonlocal workers based upon geographical proximity to the site. We defined local workers to be those workers who lived within the local impact area (i.e., within 15 highway miles of the site). Workers who lived outside the local area were, of course, classified as nonlocal workers.

¹⁰In our examination of intention to remain in the area we classified movers and temporary movers, transient movers, movers with a permanent residence elsewhere, and workweek movers.

differences in these key variables which we observed in our profile analysis were used to suggest procedures for making improved predictions of intention to remain in the area, relocation of dependents, type of housing and personal characteristics of movers.

CHAPTER III

MULTIVARIATE ANALYSES

The multivariate analyses which are described in this chapter were the key to developing procedures for forecasting migrant proportions and residential location patterns of movers at nuclear power plant construction sites. The need for such multivariate analyses was clearly demonstrated by the large variation in these variables across sites and surveys which we observed in the profile analysis portion of this study.

The purpose of the analyses was to identify the determinants of workers¹ relocation decisions and to estimate the size of the effect of the various determinants. In this way it is possible to use these results to develop procedures by which one can obtain the relevant information regarding these factors at a future construction site and predict the values of variables of interest at the proposed site.

This chapter presents a summary of the multivariate analyses performed in this study. The chapter is divided into 2 sections. The first section presents a brief discussion of our migrant proportion analysis and the second section presents a brief discussion of our residential location analysis. A more complete discussion of the theoretical justification for the models, the technical details of the empirical specification and estimation, and a more detailed discussion of results of the migrant proportion and residential location analyses are presented in Appendices C and D, respectively.

MIGRANT PROPORTION

The purpose of this analysis was to identify the factors that influence the migrant proportions of workers at nuclear power plant construction sites, to define variables to measure these factors, and to isolate from among these variables those which best explain the observed variation in migrant proportions across different sites. These findings were then used to develop methods for forecasting migrant proportions at future nuclear power plant construction projects. Indeed, in many respects the empirical specification was dictated by the forecasting procedures.

Model

Migrant proportion was defined to be the ratio of the number of movers to the total number of workers at the site. Workers were classified as movers if they had changed their work week residence to work at the construction site. The unit of analysis for the purpose of estimating these equations was workers grouped by craft.

Based upon theory and the results of our profile analysis we specified migrant proportions as a function of several factors. These factors can be expressed as a functional relationship of the following form:

$$(1) \quad MPROP = f(INCPOT, LABRQ, COMPDMD, LBAVAIL, RGCHAR, CONTVAR)$$

where:

- MPROP = Migrant proportion of a particular craft at a site;
- INCPOT = A vector of variables reflecting the income potential associated with employment at the site;
- LABRQ = A vector of variables reflecting labor requirements at the site;
- COMPDMD = A vector of variables reflecting competing demand for labor in region;
- LBAVAIL = A vector of variables reflecting local availability of labor in region;
- RGCHAR = A vector of regional characteristic variables; and
- CONTVAR = A vector of control variables.

Several variables were defined to capture the influence of the explanatory factors shown in the above equation. The income potential variables which we defined included variables such as hourly wage rate, overtime rate, fringe benefits received, and availability of travel allowances. In addition, we developed several variables in an effort to capture differences in labor requirement profiles among different crafts at each site. These variables were defined to capture the expected availability of employment at the site over the entire construction phase (i.e., the expected continuity and duration of employment), as well as to capture differences in overall and peak workforce requirements and differences in labor requirements at the time of the survey.

The variables which were defined to capture the concurrent demand for labor in the region were based upon craft-specific labor requirements of other power plant construction projects within distances of 50 and 120 miles of each construction site. Variables which captured the change in the demand for labor over the construction phase were also examined. Variables reflecting the local availability of labor were much more difficult to obtain. Several proxies were used to capture the variation in the local availability of labor. These variables included regional population, regional unemployment rate, and distance from the site to the hiring hall of the union local with jurisdiction over the project.

Several regional characteristic variables were defined in an effort to determine the relative attractiveness of the area to immigrating workers. Population, average community size and housing availability variables were included among these regional characteristic variables. Several control variables including size and type of reactor, and dummy variables for various worker groups were also included in the estimated equations. A more detailed discussion of the variables, including their definitions and expected influence on migrant proportions, can be found in the more technical description of the analysis contained in Appendix C.

Empirical Specification

For the purpose of explaining the variation in migrant proportions across surveys for various craft groups, ordinary least squares regression was used to estimate an equation of the following form:

$$(2) \quad \text{Ln} \frac{\text{MPROP}}{1-\text{MPROP}} = \alpha_1 + \alpha_2 \text{Ln INCPOT} + \alpha_3 \text{Ln LABRQ} \\ + \alpha_4 \text{Ln COMDMD} + \alpha_5 \text{Ln LBAVAIL} \\ + \alpha_6 \text{Ln RGCHAR} + \alpha_7 \text{Ln CONTVAR} + \epsilon$$

where the terms are the same as in equation (1), except:

α_s = coefficients of variables included in the equation;

ϵ = the error term; and

Ln = the natural logarithmic transformation.

Two special features of the linear relationship shown in equation (2) should be noted. First, a logit transformation was used because the values of the dependent variables, being proportions, are constrained

between 0 and 1. This transformation has the effect of ensuring that the predicted migrant proportion values will not fall outside the range of zero to one. Second, a logarithmic transformation of the explanatory variables was used to capture the non-linear relationship between the variables and migrant proportions.

Because of major differences between construction and nonconstruction workers, as well as the variables that are likely to influence their migrant proportions at a site, two separate equations were specified and estimated. The construction worker equation was estimated using the following 7 construction craft groups as units of analysis: (1) plumbers and pipefitters; (2) ironworkers; (3) boilermakers; (4) operating engineers; (5) electricians; (6) carpenters; and (7) laborers and teamsters. The nonconstruction worker equation was estimated using the following two occupational groups as units of analysis: (1) management workers and (2) clerical workers. In many instances, the specific variables included in the nonconstruction worker equation differed from those included in the construction worker equation. This was dictated by the differences in the nature of construction and nonconstruction employment, labor requirements at the site and the availability of data on nonconstruction workers.

Several alternative specifications using different sets of explanatory variables were examined to identify the variables to be included in the final equations which are presented in this report. In general, all variables with strong theoretical justification were included in the equation. Variables with insignificant explanatory power were excluded from the equation. In the case of highly correlated variables, the variable with the higher explanatory power was included in the final specification.

This selection procedure resulted in the inclusion of 18 variables in the construction worker equation and 5 variables in the nonconstruction worker equation. The results of these 2 migrant proportion equations are discussed in the following section.

Results

The results of the final specification of the construction and nonconstruction worker equations are presented in Tables 2 and 3. Both equations performed remarkably well, explaining 71 and 87 percent of the

TABLE 2

Migrant Proportion Regression Results
ConstructionDependent variable $\ln \frac{MPROP}{1-MPRO P}$ Mean -1.43

Variable	Coefficient	t
<u>Income Potential</u>		
Wage	1.58	1.83*
Overtime	3.41	3.92***
<u>Labor Requirements</u>		
Continuity of Employment	1.19	4.48***
Duration of Employment I ^a	-3.10	3.41***
Duration of Employment II ^a	-.31	.36
Duration of Employment III ^a	1.87	2.32**
Prepeak Stage	.48	5.58***
Postpeak Stage	-.52	2.81***
<u>Competing Demand for Labor</u>		
Employment at other power plants in the region	.48	4.62***
<u>Local Availability of Labor</u>		
Distance from the union local	.21	1.79*
<u>Regional Characteristics</u>		
Regional Population	1.71	3.59***
Regional Population Growth	-1.11	4.56***
Average Community Size - 25 miles	-3.11	5.54***
Average Community Size - 10 miles	1.49	5.31***
Housing Vacancy Rate	.16	5.67***
<u>Control Variables</u>		
Common (Dummy Variable)	-6.26	2.31**
Scarce (Dummy Variable)	1.10	.38
Size of Units	1.45	2.61***
Constant	39.66	6.20***
R ²	.71	R ² .67
d.f.	115	

*** = p<.01; ** = p<.05; * = p<.10

^aThree duration of employment variables were defined to estimate the effect of this variable separately for workers from the 3 scarcity groups.

TABLE 3

Migrant **Proportion** Regression Results
Nonconstruction

Dependent variable $\ln \frac{\text{MPROP}}{1-\text{MPROP}}$ Mean = .26

Variable	Coefficient	t
<u>Competing Demand for Labor</u>		
Other nuclear power plants under construction	-.40	2.02**
<u>Local Availability of Labor</u>		
Regional Unemployment Rate	-.61	2.05**
<u>Regional Characteristics</u>		
Regional Population	-.47	2.56**
<u>Control Variables</u>		
Occupation (Dummy Variable)	1.70	13.59***
Size of Units	1.05	4.12***
Constant	-1.70	.69
R^2	.86	$\bar{R}^2$.84
d.f.	36	

*** = $p < .01$; ** = $p < .05$

variation in migrant proportions among the construction and nonconstruction groups. Variable coefficient estimates were generally found to be statistically significant and were of the expected sign. The estimated coefficients were also found to be robust. The sign and significance of key variables were not sensitive to the inclusion and exclusion of other variables in the equation. Indeed, the high explanatory power of the estimated equations as well as the consistency of results, serve to justify using these multivariate analysis results to develop procedures for forecasting migrant proportions at future nuclear power plant construction sites.

1. Construction Worker Equation

As can be seen in Table 2, a total of 18 variables were included in the final specification of the construction worker equation. Of these 18 variables, 16 were statistically significant at or above the 90 percent confidence level, and together the 18 variables explained about 71 percent of the variation in migrant proportions. Variables representing each of the explanatory factors identified in equation (1) were included in the final specification. Those variables which were defined to capture regional characteristics and labor requirements were found to be the most important in explaining the differences in craft-specific migrant proportions across surveys. With the exception of the duration of employment variables, all variables were of the expected sign. The variables included in final equation and their coefficient estimates are briefly discussed below.

Income Potential. For construction workers, the income potential associated with employment at the construction site is determined not only by their wage rate, but also by factors such as overtime rate, fringe benefits received, and the availability of travel allowances. In addition, because of the nature of construction employment (i.e., the irregularity of employment), a number of other factors can also influence income potential for construction workers. These include factors such as the expected continuity and duration of employment. These variables, however, reflect differences in labor requirements associated with project construction and are included as part of our discussion of labor requirement variables.

Among the four variables defined to capture the variation in income potential across sites and surveys, wage rate and overtime rate were found to be important in explaining migrant proportions. Both had the expected positive sign and were significant, with the overtime rate variable showing a higher explanatory power than the wage rate variable. This supports the belief that overtime is a key component of high income among construction workers, and as a result serves as an important factor in attracting labor from other activities and areas.

Labor Requirements. With respect to labor requirements, 3 factors were identified as important in estimating migrant proportion differentials across crafts and sites. These 3 factors include the expected growth of employment opportunities at the time of the survey, the expected continuity of employment and the expected duration of employment at the site.

With respect to the expected growth of employment opportunities at the time of the survey, two variables were defined to capture whether employment opportunities at the construction site for a particular craft group were at a prepeak stage (demand for labor was expected to increase) or at a postpeak stage (demand for labor was expected to decrease). The estimated coefficients of the two variables indicate that the greater the expected increase in utilization of labor for a particular craft, the higher the migrant proportion; and, similarly the greater the expected decrease in utilization of labor for a particular craft, the lower the migrant proportion. This evidence supports the notion that migrant proportions increase during increasing employment periods (prepeak stage) and decrease during decreasing employment periods (postpeak stage).

The potential for greater continuity of employment increases the income a construction worker might expect to receive at a nuclear power plant construction site. This notion was confirmed by the highly significant and positive sign of the coefficient estimate of the continuity variable. In other words, crafts with greater continuity of employment were associated with higher migrant proportions. However, a similar association between projected duration of employment (duration of employment also serving to increase potential income associated with the move) and migrant proportions was not found to exist.

In fact, the duration variable coefficient estimate not only was of opposite sign, but was also significant. This would suggest that there are factors, other than income potential, which are related to the duration variable and are not separately considered in the estimated equation. These factors influence migrant proportions in the opposite direction. And, the influence of these factors is larger than the expected effect of the income potential associated with the duration variable.

One such factor might be the relationship between duration of employment for particular crafts and the relative availability of these workers in the area in which the site is located. Accordingly, we attempted to estimate the effect of the duration variable on migrant proportions separately for the scarce, common, and abundant craft groups. In spite of this, we were unable to obtain the expected association for any of the craft groups. However, we did observe that the effect of expected duration of employment upon migrant proportions was smaller among workers from the common crafts than among workers from the other construction craft groups.

Competing Demand for Labor. The competing demand for workers from various crafts at other power plant construction projects in the region was found to be related to migrant proportions. The competing demand coefficient estimate was found to be highly significant and positive. The competing demand variable which was based upon a 50-mile radius surrounding the construction site entered the equation; however, the similar variable based upon on 120-mile radius did not prove to be useful in explaining the differences in migrant proportions across crafts. This evidence suggests that power plant construction projects within commuting distance of the nuclear power plant draw workers from the same labor pool. However, in the case of more distant power plant construction projects, the impact of this factor on migrant proportion is insignificant. Furthermore, change in competing demand for labor between the year construction began on the project and the year in which the survey was conducted did not enter the final equation.

Local Availability of Labor. The lack of data regarding the size of the available labor supply and unemployment rates of construction workers in the regions in question led us to define several proxy variables to capture the variation in the local availability of labor. However

several of these variables, such as regional population and average community size, could serve as proxies for both regional attractiveness and the local availability of labor. The supply of labor implications of these variables are included in our discussion of the regional characteristic variables.

During our profile analysis, we had observed a relationship between craft-specific migrant proportions at a site and the distance between the site and the hiring hall of the union local with jurisdiction over the project. Because workers must report to union hiring halls for job referral, it can be argued that union hiring halls are likely to be located near construction employment opportunities and also that workers are more likely to live near their hiring halls. Thus, for the purpose of this analysis we used distance from the site to the hiring hall of the union local with jurisdiction over the project as a proxy for the local availability of labor. As expected, the coefficient estimate was found to be positive and significant. Since the further a construction site is located from the union hiring hall of a particular craft the lower the local availability of labor, one would expect to observe higher migrant proportion among the craft groups which have hiring halls at greater distance from the construction site.

Regional Characteristics. Regional characteristics were introduced as measures of the attractiveness of the region. However, as mentioned above, some of these variables could also be considered to be proxies of the local availability of labor. Since opposite signs are implied by these two factors and there is no a priori reason to argue which effect would be dominant, the sign of these variables could be either positive or negative. If the effect due to labor supply was larger than the effect due to regional attractiveness, then one would expect to observe a negative association between these variables and migrant proportions.

Among the 3 regional characteristic variables which could serve as proxy variables for both regional attractiveness and the local availability of labor--regional population, and average community sizes within 10 and 25 miles of the site--only the average community size within 25 miles of the site was found to be negatively associated with migrant proportion. A similar negative association was not found in the case of average community size within 10 miles of the site. The opposite signs

of these coefficients could be interpreted as suggesting that average community size very near the site (within 10 miles) serves more as a proxy for attractiveness because the largest of these communities are invariably too small to provide a significant pool of construction workers. Such is, of course, not the case when one considers communities located within 25 miles of the site. The attractiveness effect is clearly dominant in the case of regional population.

The coefficient estimates of the two remaining regional variables (housing vacancy rate and population growth) were also found to be highly significant. Housing vacancy rate was found to be the most important variable in explaining the migrant proportions across sites. Higher vacancy rates were associated with higher migrant proportions. Population growth was found to be negatively associated with migrant proportions. This result appears to suggest that population growth may be regarded by movers as a negative quality of a region. This is not unreasonable, since rapid population growth can be associated with shortage of housing and various services, which may be important elements in the decision process of immigrating workers.

Control Variables. Three variables in this category were included in the final equation. Two were dummy variables to capture the remaining mean differences among workers from the three scarcity groups. Only the dummy variable for workers from common craft was found to be statistically significant. This suggests that holding other variables constant, on average, workers from the common craft group have lower migrant proportions than workers from the other craft groups. The final control variable which we included was a variable which reflects the size (in megawatts) of the units under construction. The positive and highly significant coefficient estimate indicates that larger plants, on average, have higher migrant proportions associated with construction than one might have expected.

2. Nonconstruction Worker Equation

In the case of the nonconstruction worker equation the final specification was much simpler. As can be seen in Table 3, only 5 variables were included in the final specification. A single dummy variable which was defined to capture the average differences between management and

clerical workers was found to explain almost 75 percent of the variation in the dependent variable. However, four other variables--regional population, regional unemployment rate, number of other nuclear power plants under construction in the region, and plant size--also entered the final equation. These variables helped to explain only an additional 12 percent of the variation in migrant proportions among nonconstruction workers. All four variables were significant at or above the 95 percent confidence level.

The specific variables which were included in the nonconstruction worker equation differed to a large extent from those which were included in the construction worker equation. This, however, is not surprising when one considers the differences in the nature of employment for construction and nonconstruction workers. For example, among nonconstruction workers, migrant proportions observed at a site are less likely to be associated with income potential and much more likely to be influenced by the personnel policies of utilities and engineering firms. Especially among the management group, a large number of workers are likely to be brought in by the utility or prime contractor to work on the project with only a small number being hired locally. Moreover, the nonconstruction group is a very heterogeneous group and, as a result, no typical income values could be obtained for clerical and management groups. Thus, reflecting both the lack of adequate data and the importance of personnel policies in influencing migrant proportions, no income potential variables were included in estimating the nonconstruction equation.

The single most important variable in the nonconstruction worker equation was the management-clerical **dummy**. This implies that the variation in migrant proportions among nonconstruction workers is mostly due to differences in migrant proportions of the management and clerical groups. Indeed, as we observed in our profile analysis, the management workers had very high migrant proportions and the clerical workers very low migrant proportions.

The coefficient estimates of the overall unemployment rate in the region and the regional population were both found to be negative and highly significant. The unemployment rate variable can be interpreted to mean that if there is a higher availability of labor in the area, one

would expect to observe lower migrant proportions. The regional population variable, on the other hand, could reflect the general attractiveness of the area to immigrating workers or could reflect the size of the pool of local labor. The observed negative coefficient estimate suggests that with increasing regional population, the effect of the associated larger number of locally available workers is greater than the effect of the associated increased attractiveness of the area.

The number of other nuclear power plants currently under construction in the region was entered into the equation as an indication of the competing demand for labor. However, the estimated coefficient of the variable had an unexpected negative sign. It is possible that the negative coefficient of this variable is a reflection of the stage of project completion of the other power plants. In general these plants were farther along than our study sites. Thus, it is possible that workers were transferred from these plants to the sites included in our study. However, owing to the proximity of the sites, many workers did not have to move because they lived within commuting distance of both construction sites.

Finally, the size of the units under construction entered the equation and had an expected positive sign. Thus, as was observed in the construction worker equation, larger plants also have greater migrant proportion among their nonconstruction workers. This relationship was found to be very significant.

Unfortunately, detailed labor requirement data were not available for the nonconstruction workforce. Indeed, the only variable which was available for the nonconstruction group was the number of workers on site at the time of the survey. This variable, however, did not enter the final nonconstruction worker equation.

Summary

In our multivariate analysis we were able to identify the major determinants of the variation in migrant proportions across sites and across various worker groups. The estimated equations explained 71 and 87 percent of the variation in craft-specific migrant proportions among the construction and nonconstruction groups. These estimated equations were, in turn, used to specify the steps to forecast migrant proportions

at future nuclear power plant construction sites. These forecasting steps are described in detail in the following chapter.

RESIDENTIAL LOCATION

One of the critical elements in estimating the socioeconomic impacts of large energy development projects is determining the residential location patterns of immigrating construction workers. Past attempts to develop forecasting procedures have involved the estimation of various forms of the gravity model.¹ These attempts, however, have not been very successful because exponent estimates derived from the gravity model have been shown to vary from site to site, as well as for different groups of workers.² Consequently, these gravity models have been of only limited value for predictive purposes.

Others have attempted to overcome the weaknesses of the gravity model by proposing linear programming models, such as the spatial allocation component of the SEAM model.³ These models, however, require extensive data and, as a result, have never been validated. Thus, there is no simple validated methodology currently available for accurately predicting residential location patterns of immigrating workers at large construction projects. The purpose of this analysis was to develop and estimate a residential location model that would overcome the weaknesses of the current gravity models by explicitly incorporating various regional and project characteristics into the model.

¹J. A. Chalmers, "The Role of Spatial Relationships in Assessing the Social and Economic Impacts of Large-Scale Construction Projects," Natural Resources Journal 17:2 (1970), pp. 209-222; S. H. Murdock, J. S. Wieland and F. L. Leistritz, "An Assessment of the Gravity Model for Predicting Community Settlement Patterns in Rural Energy-Impacted Areas in the West," Land Economics, 54:4 (1978), pp. 461-471.

²Murdock, et al., Op. cit.

³E. J. Stenehjem, Summary Description of SEAM: The Social and Economic Assessment Model, Argonne National Laboratory, Energy and Environmental Systems Division, April 1978.

Model Specification

The gravity model captures the trade-offs between the size of communities and the distance of communities from their place of work which workers face in making residential location decisions. The basic form of the gravity model is as follows:

$$(3) \quad I_{ij} = \frac{A \cdot \text{POP}_j^a}{\text{DIST}_{ij}^\beta}$$

where:

- I_{ij} = the number of workers residing in community j , who worked at site i ;
- POP_j = population of community j ;
- DIST_{ij} = distance between community j and site i ;
- a = the exponent of population;
- β = the exponent of distance; and
- A = the constant of proportionality.

In the gravity model, population acts as a proxy for both the attractiveness of a community and the ability of the community to absorb immigrants. Distance, on the other hand, acts as a proxy for the costs (both in terms of time and money) associated with locating away from one's place of work. The values of the estimated exponents are determined by the choices made by individuals which, in turn, depend upon their personal tastes and preferences, the nature of their employment, and the geography of the region (i.e., the number, sizes, and types of communities available in the area surrounding the sites). Accordingly, the exponents are likely to vary across sites and perhaps across different groups of workers at the same site. It is for this reason that exponent estimates obtained from the estimation of a gravity model at one site do not usually perform very well in predicting residential location patterns at another site.

Recognizing that the population and distance exponents are likely to be influenced by various regional and project characteristics, we specify a gravity model in which a and β are, in turn, functions of several factors such as housing availability, regional attractiveness, and workforce composition.

The reduced form of such a modified gravity model can be written as follows⁴:

$$(4) \quad \text{Ln PMOVE} = \text{Ln A} + (\alpha_0 + \alpha_1 \text{ REGATT} + \alpha_2 \text{ HAVAIL} + \alpha_3 \text{ WKCOMP} + \alpha_4 \text{ CONTVAR}) \text{ Ln POP} + (\beta_0 + \beta_1 \text{ REGATT} + \beta_2 \text{ HAVAIL} + \beta_3 \text{ WKCOMP} + \beta_4 \text{ CONTVAR}) \text{ Ln DIST} + \epsilon$$

where the population exponent $a = \alpha_0 + \alpha_1 \text{ REGATT} + \alpha_2 \text{ HAVAIL} + \alpha_3 \text{ WKCOMP} + \alpha_4 \text{ CONTVAR}$ and the distance exponent $\beta = \beta_0 + \beta_1 \text{ REGATT} + \beta_2 \text{ HAVAIL} + \beta_3 \text{ WKCOMP} + \beta_4 \text{ CONTVAR}$ and where:

PMOVE = the number of movers working at the construction site and living in a particular community as a proportion of all movers;
REGATT = attractiveness of the local area to immigrating workers;
HAVAIL = housing availability in the local area;
WKCOMP = workforce composition at the construction site;
CONTVAR = control variables; and
 ϵ = the error term.

This specification is very general and permits the exponents of the population and distance terms of the gravity model to vary across sites, across different surveys at the same site, and across various worker groups. The extent of variation in the exponents is, of course, determined by differences in the explanatory factors (i.e., regional attractiveness, housing availability, workforce composition). However, the final residential location equation which we estimated was more restricted. The restrictions were imposed based upon analyses which were undertaken prior to estimating the modified gravity model.

During these preliminary analyses, we estimated a simple gravity model (as specified in equation 3) for each of the three major worker groups--nonconstruction workers, scarce construction crafts, and other construction crafts--for each survey. In general, we found that the

⁴For the derivation of the reduced form of the model, see the detailed description of the model contained in Appendix D.

differences in the residential location patterns of the three groups were not significantly different. Thus, in our final specification of residential location equation, we did not permit the population and distance exponents to vary across worker groups.

Furthermore, in our final specification we did not allow the population exponent to vary across sites and surveys. The reason for this is that although there is no strong theoretical basis to justify using different variables to explain the variations in population and distance exponents, using the same set of variables to define interaction terms with both population and distance (as required by equation 4) produces terms which are highly colinear. Accordingly, in our final specification we estimated a fixed population exponent for all surveys and allowed only the distance exponent to vary across surveys. This restriction, however, is not very severe since in our preliminary analyses we found only minor variation in population exponents across surveys.

As a reflection of these considerations, in the final specification of our residential location equation we estimated a modified form of equation (4). The equation which we estimated can be written as follows:

$$(5) \quad \ln PMOVE = \ln A + \alpha \ln POP + (\beta_0 + \beta_1 REGATT + \beta_2 HAVAIL + \beta_3 WKCOMP + \beta_4 CONTVAR) \ln DIST + \epsilon$$

The dependent variable for the purpose of this analysis was the number of movers working at the construction site and living in a given community as a proportion of all movers. The final equation was estimated using ordinary least squares regression.

As was true in the estimation of our migrant proportion equations, a vector of variables was identified for each of the explanatory factors based upon both theoretical considerations and the availability of data. For example, variables were defined to reflect the distribution of population and communities surrounding the construction site (i.e., population of communities, number of communities, and average community sizes for various distances from the site). These variables were included in an attempt to capture the attractiveness of the area to immigrating workers. Other regional attractiveness variables which were also examined. These variables included the distance to the nearest SMSA, per

capita income, population change in the local area, and employment in the service and retail trade industries. Several variables were defined in an effort to capture the availability of housing in the local area. These variables included housing units per capita, mobile homes per capita, vacancy rate and percent owner-occupied housing. Workforce composition variables were included to capture differences in the number and characteristics of movers on site at the time of the survey. These variables included total number of movers, as well as scarce movers, common and abundant movers, and nonconstruction movers as a proportion of all movers. A regional dummy variable indicating whether a site was located in the North or the South was included as a control variable. The precise definition of the variables considered are contained in Appendix D.

Results

The results of the final specification of the residential location equation are presented in Table 4. In general, the equation performed quite well, explaining over 60 percent of the variation in residential location patterns among the 24 surveys included in the equation. For the most part, variable coefficient estimates were found to be statistically significant and were of the expected sign. The estimated coefficients were also found to be robust. The sign and significance of key variables were not sensitive to the inclusion and exclusion of other variables in the equation. These results suggest that the explanatory variables included in the estimated equation do, indeed, capture many of the factors underlying the variation in distance exponents across sites.

As expected, our multivariate analysis did indicate that the proportion of movers locating in a particular community is positively related to community size and negatively related to the distance from the construction site. Both variables were significant at the 99 percent confidence level. Eight other variables were included in the final specification in an attempt to capture differences in the distance exponent as a function of regional attractiveness, housing availability, workforce composition, and control variables. Of these 8 variables, 7 were significant at or above the 95 percent confidence level.

In the gravity model estimation the distance coefficient has a negative sign (indicating an inverse relationship between distance and the

TABLE 4

Residential Location Regression Results

Dependent variable Ln FMOVE		Mean -4.999
Variable	Coefficient	t
<u>Population</u>	.385	21.103***
<u>Distance</u>	-.917	5.455***
<u>Distance Interaction Terms</u>		
Local retail activity	-.094	2.300**
Distance from SMSA	.083	.907
Housing vacancy rate	-.053	2.153**
Per capita mobile homes	-6.399	2.068**
Total number of movers	-.019	2.787***
Proportion scarce	-.433	2.523***
Proportion other construction	-.312	2.017**
Region	.133	2.354**
Constant	-2.897	15.275***
R ²	.605	R ² .600
d.f.	832	

*** = p<.01; ** = p<.05

dependent variable). A higher distance exponent can be interpreted to mean that movers will tend to locate nearer the construction site and a smaller distance exponent means that movers will tend to locate farther away. In the modified gravity model as specified in equation (5), the estimate of the distance exponent is given by the linear combination of the distance term and the various interaction terms. Thus, the coefficient estimates of the interaction terms affect the magnitude of the distance exponent--increasing it if the coefficient is negative and decreasing it if the coefficient is positive. The coefficient estimates of the various interaction terms can, therefore, be examined to determine the influence of these variables upon the distance coefficient. The results of the regression equation with respect to each of the explanatory factors identified above are briefly discussed below.

1. Regional Attractiveness

Several variables were defined to capture the general attractiveness of the area immediately surrounding the site, including variables which were intended to capture distribution of population and communities surrounding the construction site.⁵ Two of these variables--distance from the nearest SMSA and employment in retail trade industries in the local area--entered the final equation. The negative coefficient estimate of the retail trade variable implies that sites with higher retail trade activity in the local area are more likely to have higher proportions of movers living close to the site than are sites with lower retail activity in the local area. Similarly, with respect to distance from the nearest SMSA, the positive coefficient estimate indicates that those sites at greater distances from the nearest SMSA have smaller distance exponents and therefore lower proportions of movers living in communities near the construction site. Sites which are located nearer SMSA's, on the other hand, have correspondingly higher proportions of movers living in communities immediately surrounding the construction site. These results are

⁵To summarize the population and community characteristics of a site, we defined population sizes, numbers of communities and average community sizes for various distance intervals from the site. These variables, however, did not enter our final equation.

consistent with what one would expect to observe. The estimated coefficient of the retail trade variable was significant at the 95 percent confidence level. In the case of the distance from the nearest SMSA, however, the coefficient was not found to be significantly different from zero at the 90 percent confidence level.

2. Housing Availability

The availability of housing in the local area is clearly a factor in the residential location decisions of immigrating workers. Accordingly, we considered the following housing availability variables in this analysis: housing vacancy rate; percent owner-occupied housing; number of housing units per capita; and number of mobile homes per capita. Two of these variables, namely vacancy rate and number of mobile homes per capita, entered the final equation. As expected, both coefficient estimates were negative and highly significant. Thus, these results indicate that higher vacancy rates and mobile homes per capita in the local area are associated with higher proportions of movers living in nearby communities.

3. Workforce Composition

In addition, several variables were examined in an attempt to capture the residential location preferences of different groups of workers. This was done by introducing variables defined to reflect differences in workforce composition at the site at the time of the survey. Three such variables--total number of movers at the site, proportion of movers from the scarce crafts, and proportion of movers from the common and abundant crafts--were included in the final equation. Our results indicate that the total number of movers is an important variable. As the total number of movers increases, higher proportions of movers tend to locate nearer the construction site. Similarly, if the proportion of construction movers is higher (compared with nonconstruction movers), then one observes higher proportions of movers living nearer the construction site. Among construction movers, if the proportion of movers from scarce crafts is higher, then higher proportions of movers are likely to live closer to the site. This is most likely a reflection of the differences in the potential duration of employment at the site among the various worker groups. Clearly, movers whose employment potential at the site is of a shorter duration tend to live closer to the site than other workers.

4. Control Variables

Finally, we examined the effect of several control variables upon the distance exponent. Only one--region--was shown to be significant. This suggests that holding other variables constant, on average, movers in the South tend to live farther from the construction site than movers in the North.

Perhaps a better understanding of these results can be achieved by examining the distance exponents implied by the estimated equation. The coefficient estimates were used to estimate distance exponents for each of the 24 surveys included in our analysis. These estimates are presented in Table 5. The distance exponents thus computed ranged from approximately 1.2 to 1.6. **It** is important to note that distance exponents vary not only across sites, but also at the same site at different stages of project completion. The reason for this is that although most variables included in the equation are site-specific variables, the workforce composition variables are survey-specific. Thus, as workforce composition changes, so also does the distance exponent. Comparing estimated exponents for those sites at which multiple surveys were conducted, **it** can be seen that distance exponents, in general, increase as construction on the project progresses toward peak employment. This relationship is perhaps best illustrated by a comparison of the three surveys conducted at Site 10. One will note that the estimated distance exponent of the second survey (10.2) which was conducted during peak employment was higher than the estimated distance exponent of the first survey (10.1) which was conducted during the prepeak stage. Furthermore, one will observe that as employment decreased during the **postpeak** stage (10.3), the estimated distance exponent also decreased. This implies that as employment decreases at a site, the movers living nearer the site are the first to leave. This is consistent with the evidence found during our profile analysis that temporary movers are more likely to locate closer to the site than are permanent movers.

Summary

In our multivariate analysis we were able to incorporate various regional and project characteristics implicitly into the estimation of the gravity model, allowing the distance exponent to vary from site to site. Thus, in using the estimated equation to forecast residential location patterns, one will be able to estimate a distance exponent at a future construction site

TABLE 5

Distance Coefficients as Estimated Based
Upon the Residential Location Equation

<u>Survey Identification Number</u>	<u>Estimated Distance Coefficient</u>
1.0	-1.49
2.0	-1.48
3.0	-1.54
4.0	-1.54
8.0	-1.61
9.1	-1.32
9.2	-1.39
9.3	-1.47
9.4	-1.59
10.1	-1.28
10.2	-1.44
10.3	-1.27
11.1	-1.32
11.2	-1.46
11.3	-1.43
11.4	-1.52
12.1	-1.18
12.2	-1.33
12.3	-1.44
12.4	-1.55
13.1	-1.27
13.2	-1.34
13.3	-1.48
13.4	-1.52

which will differ from those observed at the sites included in our analysis based upon the differences in regional and project characteristics at the proposed site. The forecasting steps which were developed based upon these multivariate analysis results are described in detail in the following chapter.

CHAPTER IV

DESCRIPTION OF FORECASTING PROCEDURES

In our multivariate analyses we were able to identify the factors important in explaining the observed variation in migrant proportions and residential location patterns across surveys (and in the case of migrant proportions across various craft groups). These estimated equations were then used as a basis for specifying procedures for forecasting migrant proportions and residential location patterns of movers at future nuclear power plant construction sites. Because of limited resources we were unable to conduct multivariate analyses of the variation in other important personal and household characteristics of movers. However, the differences in these variables which we observed in our profile analysis were used to suggest procedures for making improved predictions of the proportions of movers who are likely to relocate their families, the type of housing selected by movers, their intention to remain in the area and personal characteristics (marital status and average family size) of movers.

This chapter presents a detailed description of how one would use these procedures to make forecasts at future nuclear power plant construction sites. The chapter is divided into 4 sections. The first 3 sections describe the procedures for predicting migrant proportions, personal and household characteristics of movers, and the residential location patterns of movers. Each section includes a step-by-step description of the forecasting procedures, including identification of data to be collected, data sources, definition of variables, and the steps in the computation of the variable of interest. The final section presents a brief discussion of the validity of these forecasting procedures.

PREDICTING MIGRANT PROPORTIONS

The procedures described here for predicting overall migrant proportions at nuclear power plant construction sites are based on the migrant proportion equations which were presented in the previous chapter. Two equations were estimated. The construction worker equation was estimated using 7 major construction crafts as units of analysis. The nonconstruction worker equation was estimated using two worker groups--management and clerical--as units of

analysis. The results of these equations thus can be used to predict migrant proportions for 9 separate groups of workers at a site.

The eighth construction craft group--consisting of workers from all other construction crafts--was not included in the estimated construction worker equation.¹ Although the individual crafts included in this group typically do not represent large numbers of workers at nuclear power plant construction sites, as a single group they can constitute a rather large number of workers at a particular site (among the surveys in our sample the size of this group ranged from 20 to 268 workers). As such, it is important to consider this group in estimating overall migrant proportions.

A separate equation was estimated for the purpose of predicting migrant proportions for this group. Seven regression equations were estimated in which the migrant proportion of the other construction craft group was expressed as a function of the migrant proportion of each of the 7 major construction craft groups. The one equation which best explained the variation in migrant proportions of the other construction craft group--the laborer and teamster equation--was used to develop procedures for forecasting the migrant proportions of the other construction craft group at future construction sites.²

¹The reason that this group is treated differently from the 7 major construction craft groups is that the group is comprised of small numbers of workers from several different construction crafts (i.e., sheetmetal workers, asbestos workers, painters, bricklayers). Individually these crafts were too small to be included in the construction worker equation. However, as a single group they represent a relatively heterogeneous group and several explanatory variables could not be determined for the group. Thus, the construction worker equation can not be used to predict the migrant proportions of this particular group.

²The results of the estimated equation are as follows:

$$MPROP_0 = (2.86 \times TEAM) - .07$$

where: $MPROP_0$ = the migrant proportion of the other construction craft group; and
TEAM = the migrant proportion of laborers and teamsters.

The estimated equation explained 50 percent of the variation in the migrant proportions of the other construction craft group among the surveys included in the analysis.

Accordingly, to estimate overall migrant proportions and therefore total number of movers at a future nuclear power plant site using our methodology, one must first estimate the migrant proportions of 8 construction and 2 non-construction craft groups. Overall migrant proportion can then be determined by the weighted average of these individual craft migrant proportion estimates. It might be noted that the accuracy of overall migrant proportion predictions, thus determined, will be greater than the accuracy of the migrant proportion predictions at the craft level. The steps involved in forecasting overall migrant proportions and the total number of movers at a future construction site are described in detail below.

Step 1 - Specify the year(s) for which the projection(s) is to be made.

The proposed forecasting procedures estimate migrant proportions for a particular point in time. Thus, before predicting migrant proportions it is necessary to specify the year(s) or quarter(s) during the construction period for which the projection(s) is to be made (hereafter referred to as projection year and projection quarter).

Step 2 - Divide projected workforce into 10 craft groups.

Determine the average daily employment in each of the following craft groups during the projection quarter.

Construction Crafts

- Plumbers and Pipefitters;
- o Ironworkers;
- o Boilermakers;
- Operating Engineers;
- o Electricians;
- Carpenters (including Millwrights);
- Laborers and Teamsters; and
- Other construction crafts.

Nonconstruction Crafts

- Clerical workers (including security and medical/nursing staff); and
- o Management (all other nonconstruction workers, including managers, engineers, and supervisors).

Craft-specific labor requirement projections can be obtained from the Construction Labor Demand System (CLDS) data. These data are described in greater detail under Step 3 below.

Step 3 - Data Collection.

For the purpose of data collection define two impact areas. Define a regional impact area surrounding the construction site to include all counties of which half or more of the total land area is within a 50-mile radius of the site. Also, define a local impact area to include the county in which the site is located, plus any other county which contains a significant portion of the land area (i.e., 30 percent or more) within 15 highway miles of the site.

Data must be obtained from several sources. Certain data (Items 1-4) must be obtained for each of the seven major construction crafts as defined in Step 2.³ Some data (Items 5-6) must be collected for all counties in the region- al impact area, while other data (Item 7) must be collected only for counties in the local impact area. In addition, various site-specific data (Items 8-10) must be obtained. The specific data to be collected and the variables to be defined based upon these data are described in detail below.

Item 1 Hourly and overtime wage rates. These data are specified in collective bargaining agreements which can be obtained from union locals or through labor relations offices of utilities. In addition, obtain the National Consumer Price Index for 1978 and the current year from Bureau of Labor Statistics publications.

Compute the following variables:

WAGE = the straight-time hourly wage rate (in 1978 dollars) for a journeyman (i.e., \$9.38 is defined as 9.38).

OTIME = the daily overtime rate expressed as a multiple of the hourly wage rate (i.e., double time is defined as 2.0).

³Data for laborers and teamsters should be obtained separately. In the case of labor requirement variables the data are added. In the case of other variables the data are averaged.

Item 2 Craft-specific labor requirement projections by quarter for the duration of the project. These data can be obtained from the utility. However, we found utility projections to be inferior to projections obtained from the Construction Labor Demand System (CLDS) data.⁴ Use of CLDS data is **recommended**, if available. For the purpose of prediction labor requirement projections must be converted to average daily employment for each quarter (use 8 hours per day and 65 working days per quarter for conversion if not available in these units). For each of the 7 major construction crafts compute the following variables:

- CONT = the number of quarters in which projected average daily employment is greater than or equal to the average daily employment of the previous quarter.
- DEMP = the number of quarters in which projected average daily employment is greater than or equal to 25 percent of the highest projected average daily employment for any quarter.
- GREMP = the ratio of the average daily employment for the projection year to the average daily employment for the four highest consecutive quarters over the remaining construction period.

Also define the following variables:

- SCAR = 1 for pipefitters, ironworkers, and boilermakers
0 for operating engineers, electricians, carpenters, laborers and teamsters
- COM = 1 for operating engineers, electricians, and carpenters
0 for pipefitters, ironworkers, boilermakers, laborers and teamsters
- D1 = 1 for $GREMP \leq 1$
0 for $GREMP > 1$
- D2 = 1 for $GREMP > 1$
0 for $GREMP \leq 1$

⁴The Construction Labor Demand System is a Department of Labor program for estimating on-site labor requirements for the construction of current, planned or forecasted energy development projects in the U.S. The CLDS provides estimated manpower requirements by month and year for 29 construction craft groups.

$$SDEMP = SCAR \times DEMP$$

$$CDEMP = COM \times DEMP$$

$$GREMP1 = D1 \times GREMP$$

$$GREMP2 = D2 \times GREMP$$

- Item 3 Annual craft-specific labor requirement projections for all other power plant construction projects within 50 miles of the construction site over the projected construction period. Information on the location of other power plants being built in the region are available in a publication entitled Inventory of Power Plants in the United States.⁵ Obtain craft-specific labor projections for all other power plants (both nuclear and non-nuclear) from the CLDS data. Convert data into total number of man-hours projected (use 8 hours per day and 260 working days per year if not available in these units). For each of the 7 major construction crafts compute the following variable:

DDR50 = the average annual labor requirements (in thousands of man-hours) at all other power plant construction projects within 50 miles of the site from the year construction is scheduled to begin on the project through the projection year.

- Item 4 The location of the nearest hiring hall of the union local with jurisdiction over the project. This information may be contained in the collective bargaining agreement of the union local. **If** not, the information can be obtained by contacting the union hall or from the labor relations office of a utility. Using a state highway map calculate the distance of the hiring hall from the construction site. Define the following variable:

DLOCAL = the distance (in miles) from the construction site to the hiring hall of the union local with jurisdiction over the project.

⁵Inventory of Power Plants in the United States, U.S. Department of Energy, Office of Utility Operations, December, 1977.

Item 5 Population of all counties in the regional impact area (the current population and the population 5 years prior). These data can be obtained from Census **publications**.⁶ Calculate the following variables:

RPOP = the total current population of all counties in the regional impact area.

RPOPGR = population growth in the last five years expressed as a percent of the population 5 years prior (i.e., current population minus population 5 years prior, divided by the population 5 years prior and multiplied by 100) for the regional impact area.
(Note: a population decrease will result in a negative value.)

Item 6 Civilian labor force and unemployment rate by county for the past 3 years. These data can be obtained from the appropriate employment agency of the state or states in which the respective counties are located. Compute the following variable:

RUN = the average unemployment rate for the past 3 years (weighted by civilian labor force) of all counties in the regional impact area. (Note: the unemployment rate variable is expressed as a percent.)

Item 7 Number of vacant units and total number of housing units in the local impact area. If recent information is not available from a local source, obtain the most recent census **data**.⁷ Define the following variable:

VACRT = total number of vacant units divided by the total number of housing units in the local impact area multiplied by 100.

⁶Data for Census years are contained in U.S. Bureau of the Census, Census of Population, Characteristics of the Population. Population estimates for non-census years are contained in U.S. Bureau of the Census, Current Population Reports, Series P-25 and P-26.

⁷U.S. Bureau of the Census, Census of Housing, Characteristics for States, Cities, and Counties.

Item 8 Number and populations of communities within 25 miles of the site.⁸ Populations of communities with populations of 2500 or more are available in census publications. Population estimates of smaller **communities** are available in the Rand McNally, Commercial Atlas and Marketing Guide. Compute the following variables:

COM10 = the total population of all communities within 10 miles of the construction site divided by the number of **communities** within 10 miles of the site.

COM25 = the total population of all communities within 25 miles of the construction site divided by the number of communities within 25 miles of the site.

Item 9 Number of other nuclear power plants under construction within 50 miles of the construction site. These data can be obtained from DOE **publications.**⁹ Define the following variable:

ONC = the total number of other nuclear power plant units currently under construction within 50 miles of the construction site.

Item 10 Size of the units to be constructed at the site. This information can be readily obtained from the utility. Define the following variable:

MWATT = the total number of megawatts in all units to be constructed at the site over the period for which the projection is being made.

Step 4 - Apply the construction worker equation.

For each of the 7 major construction crafts, predict **X** as follows:

$$\begin{aligned} X = & \quad \mathbf{39.64} \\ & + 1.58 \times \text{Ln WAGE} \\ & + 3.41 \times \text{Ln OTIME} \end{aligned}$$

⁸**Communities** for the purpose of this analysis are those with their own post office (i.e., zip code).

⁹For example see Nuclear Reactors Built, Being Built, or Planned in the United States as of June 30, 1918 (Oak Ridge: DOE Technical Information Center, 1978).

$$\begin{aligned}
&+ 1.19 \times \ln \text{CONT} \\
&- 3.10 \times \ln \text{DEMP} \\
&- .31 \times \ln \text{SDEMP} \\
&+ 1.86 \times \ln \text{CDEMP} \\
&+ .48 \times \ln \text{GREMP1} \\
&- .52 \times \ln \text{GREMP2} \\
&+ .48 \times \ln \text{DDR50} \\
&+ .21 \times \ln \text{DLOCAL} \\
&+ 1.71 \times \ln \text{RPOP} \\
&- 1.11 \times \text{RPOPGR} \\
&- 3.11 \times \ln \text{COM25} \\
&+ 1.49 \times \ln \text{COM10} \\
&+ .16 \times \ln \text{VACRT} \\
&- 6.25 \times \text{COM} \\
&+ 1.11 \times \text{SCAR} \\
&+ 1.45 \times \ln \text{MWATTS}
\end{aligned}$$

Step 5 - Calculate migrant proportions (MPROP) for the construction groups.
Calculate MPROP for each of the 7 major construction crafts.

$$\text{MPROP} = \frac{Y}{1 + y}$$

$$\text{where: } y = e^x$$

(Note: MPROP ranges from 0 to 1.)

Step 6 - Apply the other construction crafts equation.

Calculate the migrant proportion for the other construction craft group as a function of the predicted migrant proportion for laborers and teamsters.

$$\text{MPROP} = (2.86 \times \text{TEAM}) - .07$$

where: TEAM is the predicted migrant proportion for laborers and teamsters (Note: TEAM is expressed as a value between 0 and 1.)

Step 7 - Apply nonconstruction worker equation.

For the management and clerical groups calculate X as follows:

$$\begin{aligned}
X = & - 1.70 \\
& + 1.70 \times \text{MGCL} \\
& - .61 \times \text{Ln RUN} \\
& - .40 \times \text{Ln ONC} \\
& - .47 \times \text{Ln RPOP} \\
& + 1.05 \times \text{Ln MWATTS}
\end{aligned}$$

Step 8 - Calculate migrant proportions (MPROP) for the nonconstruction groups.

Calculate MPROP for the management and clerical groups.

$$\text{MPROP} = \frac{Y}{1 + y}$$

$$\text{where: } y = e^X$$

Step 9 - Predict total number of movers.

Predict the number of movers in each craft group (NMOVE_i) as follows:

$$\text{NMOVE}_i = \text{MPROP}_i \times \text{EMP}_i$$

where: MPROP_i = the migrant proportion of craft group i ; and
 EMP_i = the average daily employment for craft group i
for the projection quarter.

The total number of movers at the construction site (NMOVE_T) can then be predicted as follows¹⁰:

$$\text{NMOVE}_T = \sum_{i=1}^{10} \text{NMOVE}_i$$

PREDICTING PERSONAL AND HOUSEHOLD CHARACTERISTICS OF MOVERS

In addition to migrant proportions, several personal and household characteristics of movers are also important in making socioeconomic impact

¹⁰Overall migrant proportions (MPROP_T) can be simply calculated as follows:

$$\text{MPROP}_T = \text{NMOVE}_T / \text{TEMP}$$

$$\text{where: } \text{TEMP} = \sum_{i=1}^{10} \text{EMP}_i$$

assessments. Not all, however, are equally important in influencing the magnitude of the impacts. Compared with migrant proportions and residential location patterns, these characteristics are of secondary importance. We selected 5 such characteristics and used the results of our analyses to suggest procedures for predicting these variables at future nuclear power plant construction sites. These characteristics include relocation of dependents, intention to remain in the area, type of housing selected, marital status and average family size of workers with family present.

Because these variables are of secondary importance in impact assessment, the approach adopted to derive predicting procedures for these variables was not based on an extensive multivariate analysis. Instead, we used the systematic variations which we observed in these variables during our profile analysis as the basis for specifying procedures for forecasting these variables at future construction sites.

In our profile analysis we observed large variations in the proportion of movers with family present for various worker groups, with higher proportions of movers with family present among the nonconstruction group than among the construction group. Similarly, when construction movers were further disaggregated by relative scarcity of labor, we observed somewhat higher proportions with family present among the common and abundant craft group than among the scarce craft group. In addition, with respect to some factors a north/south difference was also observed. For instance, we observed a significant regional difference in the type of housing selected by movers, with single family houses and mobile homes more likely to be chosen in the South than in the North. Regional differences were also observed with respect to the relocation of dependent and marital status.

Accordingly, in specifying our forecasting procedures we attempted to incorporate information regarding workforce composition and location of the site (which are available prior to construction) to make more precise predictions of mover characteristics. In general, average values for the various worker groups across all sites for which data were available were calculated and these averages are used as a basis for making predictions. In the case of those variables for which regional differences were found to exist, separate averages were computed for northern and southern sites. By adopting this procedure we are able to take into account differences in workforce composition and regional differences in predicting these variables at future construction sites.

Relocation of Dependents

First, we estimate the number of movers who are likely to relocate their families. Average values for the 3 groups--the nonconstruction group, scarce group, and common and abundant group--were calculated for the northern and southern sites and served as the basis for the development of forecasting procedures. The number of movers who will relocate families can be predicted as follows:

Step 1 - Obtain predicted numbers of movers for 3 craft groups.

Obtain the predicted number of movers in the nonconstruction ($NMOVE_{NC}$), scarce ($NMOVE_S$) and common and abundant ($NMOVE_{CA}$) craft groups based upon the number of movers in the 10 craft groups as predicted in the previous section.

$$NMOVE_{NC} = \sum_{i=1}^2 NMOVE_i$$

$$NMOVE_S = \sum_{j=1}^3 NMOVE_j$$

$$NMOVE_{CA} = \sum_{k=1}^5 NMOVE_k$$

where for subscript i 1 = management, and
 2 = clerical.

for subscript j 1 = pipefitters,
 2 = ironworkers, and
 3 = boilermakers.

for subscript k 1 = electricians,
 2 = carpenters,
 3 = operating engineers,
 4 = laborers and teamsters, and
 5 = other construction crafts.

Step 2 - Estimate the number of movers with family present (NFAM).

The number of movers with family present can be obtained as follows:

(a) For northern sites,

$$\begin{aligned} NFAM &= .66 \times NMOVE_{NC} \\ &+ .41 \times NMOVE_S \\ &+ .56 \times NMOVE_C \end{aligned}$$

(b) For southern sites,

$$\begin{aligned}\text{NFAM} &= .75 \times \text{NMOVE}_{\text{NC}} \\ &+ .61 \times \text{NMOVE}_{\text{S}} \\ &+ .65 \times \text{NMOVE}_{\text{CA}}\end{aligned}$$

Intention to Remain in the Area

In the case of intention to remain in the area we estimate the number of movers who are temporary (i.e., expect to leave the area either before or upon completion of the project). The number of movers who expect to leave the area upon completion of the project can be estimated as follows:

Step 1 - Obtain the predicted numbers of movers for 2 craft groups.

Obtain the predicted number of movers in the construction (NMOVE_{C}) and nonconstruction (NMOVE_{NC}) craft groups as in Step 1 of Relocation of Dependents where:

$$\text{NMOVE}_{\text{C}} = \text{NMOVE}_{\text{S}} + \text{NMOVE}_{\text{CA}}$$

Step 2 - Estimate number of movers who are temporary (NTEMP).

The number of all movers who are temporary can be obtained as follows:

$$\begin{aligned}\text{NTEMP} &= .68 \times \text{NMOVE}_{\text{NC}} \\ &+ .48 \times \text{NMOVE}_{\text{C}}\end{aligned}$$

Type of Housing

The variables of interest in estimating type of housing chosen by movers are the numbers of movers living in four different housing types. These four housing types are: houses, mobile homes, apartments and other housing (i.e., hotels, motels, boarding and rooming houses). Average values of movers living in each of the four housing types were calculated for the construction and nonconstruction groups for the northern and southern sites. These average values served as a basis for the development of forecasting procedures. The number of all movers who are likely to live in each of the four housing types can be estimated as follows:

Step 1 - Obtain predicted numbers of movers for 2 craft groups.

Obtain the predicted number of movers in the construction (NMOVE_{C}) and nonconstruction (NMOVE_{NC}) groups as described in Step 1 of Intention to Remain in the Area.

Step 2 - Estimate number of movers choosing various housing types.

The number of movers living in each of four housing types can be obtained as follows:

(a) For northern sites,

$$\begin{aligned}\text{HOUSE} &= .51 \times \text{NMOVE}_{\text{NC}} \\ &\quad + .36 \times \text{NMOVE}_{\text{C}} \\ \text{MOBILE} &= .10 \times \text{NMOVE}_{\text{NC}} \\ &\quad + .23 \times \text{NMOVE}_{\text{C}} \\ \text{APT} &= .35 \times \text{NMOVE}_{\text{NC}} \\ &\quad + .22 \times \text{NMOVE}_{\text{C}} \\ \text{OTHER} &= .04 \times \text{NMOVE}_{\text{NC}} \\ &\quad + .19 \times \text{NMOVE}_{\text{C}}\end{aligned}$$

(b) For southern sites,

$$\begin{aligned}\text{HOUSE} &= .59 \times \text{NMOVE}_{\text{NC}} \\ &\quad + .34 \times \text{NMOVE}_{\text{C}} \\ \text{MOBILE} &= .18 \times \text{NMOVE}_{\text{NC}} \\ &\quad + .43 \times \text{NMOVE}_{\text{C}} \\ \text{APT} &= .20 \times \text{NMOVE}_{\text{NC}} \\ &\quad + .14 \times \text{NMOVE}_{\text{C}} \\ \text{OTHER} &= .04 \times \text{NMOVE}_{\text{NC}} \\ &\quad + .09 \times \text{NMOVE}_{\text{C}}\end{aligned}$$

Marital Status

The variable to be predicted in this instance is the proportion of movers who are married. Total number of married movers can be estimated based upon the numbers of construction and nonconstruction movers and the average proportions of movers who are married for these two worker groups for northern and southern sites. The number of married movers can be estimated as follows:

Step 1 - Obtain the predicted numbers of movers for 2 craft groups.

Obtain the predicted number of movers in the construction (NMOVE_{C}) and nonconstruction (NMOVE_{NC}) craft groups as described in Step 1 of Intention to Remain in the Area.

Step 2 - Estimate number of movers who are married (MARRIED).

The number of movers who are married can be estimated as follows:

(a) For northern sites,

$$\begin{aligned} \text{MARRIED} &= .74 \times \text{NMOVE}_{\text{NC}} \\ &+ .77 \times \text{NMOVE}_{\text{C}} \end{aligned}$$

(b) For southern sites,

$$\begin{aligned} \text{MARRIED} &= .76 \times \text{NMOVE}_{\text{NC}} \\ &+ .87 \times \text{NMOVE}_{\text{C}} \end{aligned}$$

Average Family Size

In examining average family size we focused upon the average family size (including the worker) of movers who relocate their families. The average family size did not differ much for various worker groups. The average family size for the construction group was 3.4 compared with 3.1 for the nonconstruction group. Thus, once the number of movers with family present has been calculated, these average values can be used to develop multipliers for determining total population increase associated with the immigrating workers and their families.

PREDICTING RESIDENTIAL LOCATION PATTERNS

The forecasting procedures for residential location involve estimating the numbers of movers which can be expected to settle in individual communities surrounding the construction site. The procedures described here are based upon the results of the modified gravity model equation which were presented in the previous chapter. Various regional and project characteristics are used to estimate distance and population exponents, which are then incorporated into a gravity model and used to predict the residential location pattern of immigrating workers. The steps involved in forecasting residential location patterns at future construction sites are described in detail below.

Step 1 - Determine total number of movers and movers for 3 craft groups.

Obtain estimates of the total number movers as described in Step 9 of Migrant Proportions. In addition, obtain the predicted number of scarce movers and the predicted number of common and abundant movers as described in Step 1 of Relocation of Dependents.

Step 2 - Identify communities for which forecasts will be made.

Identify all communities in the area surrounding the proposed construction site which satisfy the following size and distance criteria:¹¹

- all communities within 15 miles of the site;
- communities with 2500 or more inhabitants located from 15 to 40 miles from the site;
- communities with 10,000 or more inhabitants located from 41 to 60 miles from the site; and
- communities with 100,000 or more inhabitants located from 61 to 80 miles from the site.

Step 3 - Data Collection

Data must be obtained from several sources. Certain data (Items 1-2) must be obtained for each community identified in Step 2. Other data (Items 3-5) must be collected for counties in the local impact area as defined under Step 3 of the migrant proportions predicting procedures. In addition, various site-specific data (Items 6-8) must be obtained. The specific data to be collected and the variables to be defined based upon these data are described in detail below.

- Item 1 Population of the community. Population of communities with population of 2500 or more are available in census publications.¹² Population estimates of smaller communities are available in the Rand McNally, Commerical Atlas and Marketing Guide. Define the following variables:
- POP = population of the community.
- POP15 = the total population of all communities within 15 miles of the construction site.

- Item 2 Distance from the construction site. Using a state highway map, calculate the distance (in highway miles) between each community and the construction site. Define the following variable:

¹¹For the purposes of this analysis communities are defined as those with their own post offices (i.e., zip codes). For very large communities with more than one zip code, use only one zip code as a community identifier.

¹²U.S. Bureau of the Census. Census of Population. Characteristics of the Population.

DIST = distance (in highway miles) between the community and the construction site.

Item 3 Population of all counties in the local impact area. These data are available in Census publications.¹³ Define the following variable:

LPOP = total population of all counties in the local impact area.

Item 4 Number of vacant housing units, total number of housing units and number of mobile homes in the local impact area. If recent information is not available from a local source, obtain the most recent Census data.¹⁴ Define the following variables:

VACRT = total number of vacant units divided by the total number of housing units in the local impact area multiplied by 100.

PMH = total number of mobile homes in the local impact area divided by the total population of all counties in the local impact area (LPOP as defined above).

Item 5 Total number of persons employed in retail trade in the local impact area. This information can be obtained from the County Business Patterns published by the U.S. Bureau of the Census. Compute the following variable:

PCRET = total number of persons employed in retail trade in the counties of the local impact area divided by the population of the local impact area.

RET = PCRET x (POP15/1000). (Note: This variable is a proxy measure of retail employment within 15 miles of the construction site.)

¹³Data for Census years are contained in U.S. Bureau of the Census, Census of Population, Characteristics of the Population. Population estimates for non-census years are contained in the U.S. Bureau of the Census, Current Population Reports, Series P-25 and P-26.

¹⁴Bureau of the Census, Census of Housing, Characteristics for States, Cities and Counties.

Item 6 Composition of movers. Using information regarding the number of movers at the construction site obtained in Step 1, calculate the following variables:

NMOVE = the total number of movers divided by 100.

PS = the number of scarce movers divided by the total number of movers.

PO = the number of common and abundant movers divided by the total number of movers.

Item 7 Location of the nearest SMSA.¹⁵ Using a state highway map calculate the distance (in highway miles) from the construction site to the city limits of the central city of the nearest SMSA. Calculate the following variable:

DSMSA = distance of the construction site from the nearest SMSA divided by 100.

Item 8 Region. Define a regional dummy variable as follows:

REG = 1, if the site is located in the South (as defined by U.S. Census regions).

0, otherwise.

Step 4 - Calculate the distance exponent.

Calculate the distance exponent as follows:

$$\begin{aligned} \text{EXP} = & .917 \\ & + .053 \times \text{VACRT} \\ & + 6.399 \times \text{PCMH} \\ & + .094 \times \text{RET} \\ & + .019 \times \text{NMOVE} \\ & + .433 \times \text{PS} \\ & + .312 \times \text{PO} \\ & - .083 \times \text{DSMSA} \\ & - .133 \times \text{REG} \end{aligned}$$

¹⁵The Standard Metropolitan Statistical Area (SMSA) is an area specified by the U.S. Bureau of the Census and is used to designate large metropolitan areas.

Step 5 - Aggregate all communities within 10 miles of the site.

For the purpose of applying the gravity model equation, combine all communities within 10 miles of the site to create one community. Add the population of all communities and assign the community a distance of 5 miles.

Step 6 - Apply gravity model equation.

Calculate a proportion (P_i) for each community, treating all communities within 10 miles as a single community.

$$P_i = \frac{.055 \times \text{POP}^{.385}}{\text{DIST}^{\text{EXP}}}$$

Step 7 - Distribute the estimated proportions to communities within 10 miles.

Distribute the proportion computed for all communities within 10 miles of the site to individual communities within 10 miles of the construction site as follows:

$$P_j = \frac{\text{POP}^{.385}}{\sum \text{POP}^{.385}} \cdot P$$

where: P = the proportion for all communities within a 10-mile radius of the site as calculated in Step 6.

Step 8 - Normalize the estimated proportions.

Normalize the proportions calculated for all communities located more than 10 miles from the site (as calculated in Step 6) and the proportions calculated for all communities within 10 miles of the site (as calculated in Step 7) to sum to one. Compute the proportion of movers in each individual community as follows:

$$\text{PROP}_i = P_i + \frac{P_i^2}{\sum P_i^2} (1 - \sum P_i)$$

Step 9 - Calculate number of movers in each community.

Multiply PROP_i as calculated in Step 8 and total number of movers at the site to obtain the number of movers who can be expected to locate in each community.

VALIDITY OF THE FORECASTING PROCEDURES

Several steps were taken to establish the validity of the forecasting procedures described in this chapter. A more detailed discussion of the validity of the forecasting procedures is presented in Appendix E. In this section we present a brief summary of the evidence which suggests that one can expect the proposed procedures to perform well at future construction sites.

Migrant Proportions

The validity of the proposed migrant proportion forecasting procedures is supported by the following four features of the estimated equations:

- First, a large proportion of the observed variation in craft-specific migrant proportions is explained by the estimated equations underlying the forecasting procedures (71 percent in the case of the construction worker equation and 85 percent in the case of the nonconstruction worker equation). This implies a correlation between predicted and actual migrant proportions of .85 and .92 for construction and nonconstruction craft groups, respectively. Moreover, since we are interested in predicting overall migrant proportions and not migrant proportions among workers in each craft group, one can expect the overall migrant proportion predicted values to be even more highly correlated than indicated by the estimated equations.
- Second, the magnitude, sign and significance of the coefficient estimates were found to be stable with respect to (1) inclusion and exclusion of control variables in the equations, and (2) estimating the equations using subsets of the data, i.e., estimating the equations excluding all observation from a single site. The remarkable consistency in parameter estimates which we observed in the various estimated equations clearly demonstrates the robustness of the estimated model and thus provides further evidence of the validity of the forecasting procedures.
- Third, a narrow range of mean square values of the explained variation (4.28 to 5.29 for construction and 6.36 to 6.99 for nonconstruction) and residuals (.274 to .347 for construction and .126 to .173 for nonconstruction) is observed when equations estimated with all sites included and equations estimated excluding all observations from a single site are compared. This indicates that there is systematic variation in migrant proportions of crafts both within and

across sites, and that the proposed specification of the model does a very good job of consistently capturing about the same amount of the variation across the various subsets of data.

- Finally, the difference between actual and predicted overall migrant proportions was found to be relatively small. The mean absolute deviation and the root-mean-square deviation across the 21 surveys included in our analysis were 2.9 and 3.7 percentage points, respectively. This suggests that a relatively high degree of prediction accuracy is associated with the proposed forecasting methodology.

Personal and Household Characteristics of Movers

The proposed procedures for predicting personal and household characteristics of movers were not based upon estimated equations. As a result, the only evidence of the validity of the proposed forecasting procedures lies in a comparison of predicted and actual values among the sites included in our analysis. The mean absolute deviation between actual and predicted values and the associated root-mean-square deviation for the various variables of interest are as follows:¹⁶

	<u>Mean absolute deviation</u>	<u>Root-mean-square deviation</u>
Relocation of Dependents	5.4	7.5
Type of Housing		
- House	4.8	6.9
- Mobile home	6.5	7.9
- Apartment	3.8	5.5
- Other	3.6	4.4
Marital Status	3.4	4.1

Given that these variables are of secondary importance in socioeconomic impact assessments, these expected prediction errors are not likely to be of major importance.

¹⁶Because our examination of intention to remain in the area was based upon only 4 surveys, little can be concluded regarding the validity of the forecasting procedures.

Residential Location

The validity of the proposed residential location forecasting procedures is supported by the following features of the estimated equations:

- First, approximately 60 percent of the observed variation in residential location patterns across the ten sites included in our analysis is explained by the estimated equation underlying the forecasting procedures. In addition, the sign, significance and magnitude of the coefficient estimates were found to be stable with respect to the inclusion and exclusion of various control variables and also when all communities associated with single sites were excluded from the regression.
- Second, the range of the mean square of the explained variation (which ranged from 102.29 to 109.95) and the mean square of the residual (which ranged from .860 to .880) of the various equations--the equation estimated with all sites included and the equations estimated in which all observations from single sites were excluded--was small. The consistency, stability and robustness of the estimated equation all serve to increase our confidence in the validity of these forecasting procedures.
- Finally, the difference between the actual and predicted proportions of movers living within five-mile intervals of the site was relatively small for most distance bands. The generalizability of the estimated equation would, no doubt, have been improved with the inclusion of a greater number of sites in the analysis. However, the proposed forecasting procedures represent a great improvement over procedures which to date have been available for forecasting residential location patterns of immigrating workers at nuclear power plant construction sites.

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APPENDIX A
THE DATA COLLECTION EFFORT

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THE DATA COLLECTION EFFORT

This study examines labor force migration and residential choice of workers at nuclear power plant construction sites. A very important part of this study was the collection of considerable data for a large number of construction sites. Several types of data were obtained. First, it was necessary to obtain information regarding the numbers of workers who moved to the area to work at particular construction sites, their intention to remain in the area beyond completion of the project, location of work week residence, type of housing selected and personal and household characteristics of movers.

The survey data which formed the basis of this study included 28 worker surveys which were conducted at 13 different nuclear power plant construction sites. Surveys were conducted at four nuclear power plant construction sites specifically for this study. We were, however, able to increase the number of sites in our analysis by including data from similar surveys which were conducted by utilities at nine additional sites.

In addition to these survey data, considerable secondary data were also collected. Numerous data sources were examined in an effort to obtain variables which captured differences in the many factors which could influence workers' relocation decisions. The secondary data which were collected included projected craft-specific labor requirement profiles, as well as numerous regional and project characteristics, for each of the sites in the study. These data were obtained from a number of sources, including collective bargaining agreements, state agencies and various published sources.

This appendix presents a detailed discussion of the data collection effort. The discussion is divided into 2 sections. The first section describes the survey data and the second part describes the secondary data.

SURVEY DATA

The survey data used in this study include the responses of over 49,000 workers from 28 surveys conducted at 13 different nuclear power plant construction sites. The procedures which were used to conduct these surveys and the type of information collected varied somewhat depending upon who conducted the survey.¹ The nature of these differences was minor, however, and it was possible to generate data which were consistent across all surveys.

In this section we present a detailed discussion of the survey data collected. The following topics are discussed: survey administration, nature of the data collected, extent of variation in regional and project characteristics, and preparation of the survey data files.

Survey Administration

Conducting worker surveys at large construction projects is not an easy task. Several rather unique survey problems encountered at large construction projects limit the number of viable options for survey administration. The construction workforce is generally transient; work is often temporary and there may be a high turnover from one week to the next. As a result, the number of workers is not constant, but rather varies from day to day. In addition, the workforce is quite large and workers are dispersed over a very large construction site. Finally, names, addresses and occupations of workers typically are not available to identify the population in question.

Because of the craft-specific nature of the analysis, obtaining survey data from adequate numbers of workers in various craft groups at each site was very important to this study. We exercised extreme caution in selecting the surveys to be included in our data set. In addition to containing information useful in our analysis, all surveys were regarded as acceptable in several other respects. First, a census survey was conducted at each site. Second, the survey procedures adopted allowed

¹Four surveys were conducted by us. Three utilities were involved in conducting the other surveys.

sufficient control over survey administration. Third, adequate response rates were achieved.

1. Sampling Versus Census Surveys

The number of workers at a nuclear power plant construction site may vary from 500 to 4,000 workers depending upon factors such as the number of units being built and the stage of project completion. One might, therefore, conclude that surveying only a sample of workers on site would be appropriate for **most** analyses. However, the transient nature of the construction workforce and the limited information available prior to a survey make the successful implementation of a sample survey extremely difficult.

Even a simple random sample of workers is made difficult by the fact that it is generally not possible to identify the population from which one might sample. Often there is a quite high turnover among workers from one week to the next. In addition, the situation is further complicated by the nature of the employment hierarchy at a construction site--with many of the workers on site being hired by subcontractors.

Furthermore, because differences across crafts are important to the analysis to be performed, it is important to survey adequate numbers of workers from all major crafts represented at a site. Depending upon the stage of project completion, some craft groups may be represented in rather small numbers at the time of the survey and it is important to include adequate numbers of workers from these crafts in the sample.

This suggests that a stratified random sample would be appropriate. This, however, would be difficult given the prior information necessary to draw a stratified sample. In most cases it is possible to obtain only a crude estimate of the total number of workers expected to be on site at a particular time. An accurate estimate of the number of workers by craft is virtually impossible to obtain.

The difficulties in implementing a simple random sample--not to mention the additional problems associated with a stratified sample--make a census survey the only reasonable alternative. Indeed, given the viable options for administering construction worker surveys which would insure an adequate response rate, a census survey is both easier and less costly to perform.

2. Survey Procedures Used

Many of the standard survey administration procedures (i.e., mail surveys, telephone surveys, personal interviews) are not viable options at large construction sites. The primary reason is that names, addresses, and telephone numbers can not be easily obtained for workers at most construction sites. In many cases, it is possible that no single source of this information is maintained. Furthermore, even if such information were available, the utility, prime contractors, or subcontractors may not be willing to release the information because they consider it to be too personal.

This difficulty in identifying individual workers considerably limits the procedures which can be used in administering a worker survey at large construction projects. Some form of group administration is the most viable for successful implementation. Enclosing questionnaires with paychecks, or distributing questionnaires at entries or exits might seem to be acceptable options. However, such procedures do not provide adequate control over survey administration and, as a result, would most likely yield unacceptably low response rates.

The key to achieving a high response rate is to identify a procedure by which every worker at a site can be contacted either individually or in a group. Two such procedures were used in administering the 28 surveys included in this study. The first procedure, which involved administering the surveys during regular safety meetings, was adopted at three sites. The remaining surveys were administered by supervisors and foremen to their crews. The specific details of each of these methods are provided below.

Safety meeting method. This method takes advantage of the safety meetings which are required to be held at regular intervals at nuclear power plant construction sites. At some sites safety meetings are held weekly, with meetings scheduled for all crafts at the same time (occasionally these meetings are held at a central location). At other sites safety meetings are scheduled to be held at different times, on different days, for different groups of workers. During these meeting workers meet in small groups to discuss matters of safety under the supervision of a foreman or safety supervisor. With the cooperation of the utility and/or

prime contractor, these meetings provide an ideal situation in which to conduct the survey.

In adopting this method, safety meetings were extended by 10 or 15 minutes and the survey questionnaires were distributed, completed and collected at that time. Because the survey activity was so closely monitored, and because the meetings involved all construction workers at the site, this method generally produced very high response rates. Office workers, however, typically do not participate in safety meetings. As a result, when this method was used, alternate arrangements were necessary to survey nonconstruction workers.

Supervisor method. This method takes advantage of the employment hierarchy at a construction site. Workers are generally divided into small crews of from 8 to 15 workers under a supervisor or foreman. This supervisor method involves distributing questionnaires to subcontractors and supervisors, who in turn distribute them to their foreman. Foremen are then asked to administer the surveys to their crews at some convenient time during the day--for example, during lunch or some other normal break in work.

Adopting this method allowed surveys to be administered to work crews scattered over a large construction site with little or no disruption of work. However, successful implementation of this technique did require the cooperation and assistance of a large number of supervisors and foremen.

3. Response Rates Achieved

Many of the past attempts at conducting surveys of construction workers have had only limited success. Old Mountain West, for example, reported response rates ranging from a low of 14 percent to a high of 78 percent in their surveys of workers at 14 energy development project.² The average response rate among the 14 surveys was 50 percent. Similarly, in surveys of 12 Bureau of Reclamation water development projects,

²Mountain West Research, Inc., Construction Worker Profile, Final Report, prepared for the Old West Regional Commission, 1975, p. 12.

response rates ranged from 21 to 85 percent, with an average response rate of only 52 percent.³

The response rates achieved in the 28 surveys included in this study were considerably higher than response rates which have been achieved in construction worker surveys in past studies. The response rates ranged from a low of 60.2 percent to a high of 94.9 percent, with an average response rate of approximately 81.5 percent. The response rates achieved in each of the 28 surveys included in this study are presented in Table A-3.

Nature of the Data Collected

Since 28 surveys were conducted by several research groups using different survey instruments, the data collected were not identical for all sites. The survey instruments used in the various surveys are included at the end of this appendix. However, despite the difference in survey instruments, there was sufficient similarity in the information gathered in these surveys to address many issues important in socio-economic impact assessment.

The information contained in all 28 surveys was sufficient to allow us to address questions regarding:

- the proportion of workers at a site who moved to the area to work at the site;
- the type of housing in which the movers live;
- the residential location patterns of both movers and nonmovers; and
- the household composition (i.e., average family size and number of school-age children) of immigrating workers.

Considerably more information was available for some sites, which allowed us to address a number of other issues. These issues include:

- the intention of workers to remain in the area;
- whether or not workers maintain a permanent residence elsewhere;

³J. A. Chalmers, Bureau of Reclamation Construction Worker Survey, Bureau of Reclamation, Engineering and Research Center, October, 1977, p. 8.

- relocation of dependents; and
- demographic characteristics of nonmovers as well as movers.

The availability and nature of the data for the 28 surveys is summarized in Table A-1.

It might be noted that the 28 surveys contained in this data set do not constitute a representative sample of all nuclear power plants under construction in the United States. Indeed, even the choice of the four sites surveyed by us was determined more by the willingness of utilities to cooperate than by considerations of representative sampling. It should, however, be recognized that representative sampling, while not possible, was also not critical for the purposes of our study.

The ultimate goal of this study was to develop a forecasting methodology that could be applied to the future construction of nuclear power plant projects. Since there is no basis to view the distribution of existing generating plants as the best predictor of the location for future power plants, it was far more important to include sites which will be representative of plants that are likely to be constructed in the future. Therefore, much more important to our study than obtaining a representative sample of existing power plants, was capturing as much variation as possible along a number of different dimensions.

Extent of Variation in Regional and Project Characteristics

An attempt was made to improve the generalizability of our results by including a sufficient number of surveys in our sample so as to incorporate as many relevant regional and project characteristics as possible in our analysis. Seven key dimensions were identified as important to the study. While resource limitations did not permit us to observe every possible variation in each dimension, the 28 surveys in our sample do exhibit a wide range of variation in the various dimensions. The variations observed in our sample sites for each of these seven dimensions are briefly described below and are summarized in Tables A-2 and A-3.

1. Regional Distribution

Preferably, a sample of nuclear power plant construction sites should include sites from five different regions of the country: the Northeast,

TABLE A-1

Availability and Nature of Survey Data

Item	Site Identifying Number																Total
	1	2	3	4	5		6	7	8	9		10	11	12		13	
Number of Surveys	1	1	1	1	1	1	1	1	1	1	3	3	4	1	3	4	28
Migrant Status	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	28
Intention to Remain	X	X	L	L	L				X	X				L			8
Relocation of Dependents	X	X	X	X					X	X	X	X	X	X	X	X	24
Housing Type																	
- Movers	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	28
- Nonmovers	X	X	X	X	X	X	X	X	X	X				X		X	15
Residential Location	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	28
Demographic Characteristics																	
- Movers	X	X	X	X	L	L	L	L	X	X	L	L	L	X	L	L	28
- Nonmovers	X	X	X	X					X	X				X			7
Craft	X	X	X	X					X	X	X	X	X	X	X	X	24
Union Status	X	X							X	X							4

X = Complete information available.

L = Limited information available.

TABLE A-2
Regional and Power Plant Project Characteristics

Site	Project Characteristics							Regional Characteristics						
	Planned Reactor Units		Size of Units (MW)	Type of Plant	Type of Utility	Status of Work force	Union Membership	Other Reactor Units in Region ^a		Region Location	Distance to SMSA (Miles)	Cities Within 25 Miles of the Site With Population of		
	Already Completed	Under Construction						Already Completed	Under Construction			5,000 to 10,000	10,000 to 25,000	25,000+
1	1	1	1080	BV	Pr	PC	Un	1	1	N	44	0	2	0
2		2	1120	BV	Pr	US	Un	2	3	MW	62	4	0	2
3	-	2	1120	PW	Pr	US	Un			MW	20	1	3	1
4		2	1078	BW	Pr	US	Un	3		MW	84	1	3	0
5		2	1180	PW	Pr	UWF	Non	2		SE	20	3	3	2
6		3	1280	BV	Pr	UWF	Non	5		SE	58	1	3	1
7	-	2	1153	PW	Pr	UWF	Non	-		SE	23	2	1	2
8	1	1	829	PW	Pr	PC	Un	-		S	70	0	0	1
9		2	1213	BV	Pb	U	Un			S	50	2	0	0
10		3	1067	BW	Pb	U	Un			S	30	1	1	1
11		2	1184	BV	Pb	U	Un	-	2	S	20	2	3	1
12		2	1177	PW	Pb	U	Un		2	S	53	1	1	0
13		2	1233	BW	Pb	U	Un			S	55	0	2	0

KEY :

BV = boiling water

PW = pressurized water

PC = prime contractor

U = utility hires workers

US = utility hires subcontractor

UWF = utility workforce

Pr = private

Pb = public

Un = union

Non = nonunion

N = North

MW = Midwest

SE = Southeast

S = South

^a Region was defined as the area within a 50 mile radius from the site.^b The distance to the central city of the nearest SMSA.

TABLE A-3

Survey Response Rates and the Stage of Project Completion
at the Time of the Survey

Survey Identification Number ^a	Worker Response		Stage of Completion	
	Number On Site	Response Rate	Quarters Elapsed	Stage
1.0	1572	88.4%	12	Prepeak
2.0	1641	84.3%	11	Peak
3.0	1333	85.2%	9	Peak
4.0	2364	94.9%	16	Peak
5.1	1680	91.3%	18	Prepeak
5.2	2122	83.6%	25	Peak
6.0	406	83.3%	4	Prepeak
7.0	1993	72.7%	10	Prepeak
8.0	2448	90.5%	30	Postpeak
9.1	900	72.8%	3	Prepeak
9.2	2200	61.1%	7	Prepeak
9.3	3500	60.2%	12	Prepeak
9.4	3834	87.9%	15	Peak
10.1	2500	68.2%	13	Prepeak
10.2	3200	80.0%	19	Peak
10.3	2100	84.7%	28	Postpeak
11.1	1100	76.6%	6	Prepeak
11.2	2200	66.4%	13	Prepeak
11.3	1600	68.1%	21	Prepeak
11.4	2800	68.0%	31	Prepeak
12.1	475	84.6%	1	Prepeak
12.2	1700	87.7%	7	Prepeak
12.3	2800	88.8%	14	Prepeak
12.4	3439	91.0%	20	Peak
13.1	b		1	Prepeak
13.2	b		3	Prepeak
13.3	3450	93.7%	5	Prepeak
13.4	4413	86.4%	7	Prepeak

^a In case of multiple surveys at a site, the surveys are identified by numbers after a decimal point in order of the dates on which the surveys were implemented.

^b Precise number of workers could not be determined.

the Midwest, the Southeast, the South, and the West.⁴ Our sample of 13 sites included at least one site in each of these regions, with the exception of the West. The seriousness of this omission will, of course, depend upon the extent to which the characteristics of western power plant construction are not captured by the variation in the characteristics of the plants in other regions.⁵

2. Local Community Characteristics

Some power plants are built in relatively rural surroundings, while others are located quite close to large population centers. In our 13 sites we were able to observe considerable variation in the number and sizes of communities surrounding the site. For example, within a 25-mile radius of the construction site, one site in our sample had three communities of 5,000 to 10,000 inhabitants, three communities of 10,000 to 25,000 inhabitants, and two communities of more than 25,000 inhabitants. Another site in our sample had only one large community within 25 miles--a community with a population of more than 25,000. Yet another site had only two communities of 5,000 to 10,000 people. Alternatively one could consider the distance of the site from a major metropolitan area as the dimension of relevance. The 13 sites in our sample showed considerable variation in this respect. The distance of the site from the central city of the nearest SMSA varies from 20 to 84 miles.⁶

3. Stage of Project Completion

Our sample of 28 surveys included surveys conducted at different stages of project completion. The surveys were conducted from 1 to 31

⁴These regions were defined somewhat arbitrarily after considering the existing location of facilities, population distribution, regional growth and availability of alternative sources of power.

⁵While it would have been preferable to include a site from the West, having been unable to do so should not limit the application of our findings to nuclear power plant construction in the West.

⁶The Bureau of the Census uses the Standard Metropolitan Statistical Area (SMSA) to define metropolitan areas. Among the criteria used to define an SMSA is that the area must include at least one central city (or two contiguous cities) with 50,000 or more inhabitants.

quarters after construction began. However, number of quarters since construction began may not be the best reflection of stage of project completion. The primary problem with using this measure is that it is not adjusted for factors such as seasonality or construction delays. One can instead define an alternative measure of stage of project completion using the profile of actual labor requirements and the most recent projections of labor requirements for the remainder of the construction period. Based upon whether labor requirements were rising, constant, or falling at the time of the survey, surveys can be classified as either prepeak, peak or postpeak. Among the 28 surveys included in our study 19 surveys were classified as prepeak, 7 as peak and only 2 as postpeak. Moreover, in the case of 6 of the 13 sites, we were able to obtain survey data at several points in time during plant construction.

4. Plant Characteristics

Both boiling water and pressurized water reactors were included in our sample. The capacity of the individual units under construction did not exhibit much variation, ranging from a low of 829 megawatts to a high of 1280 megawatts. However, the number of units being built at the site varied from a single unit to a maximum of three units.

5. Previous Power Plant Construction in the Area

A factor which could influence the migration of workers to a particular site is the number of other nuclear power plants which have already been completed in the area prior to the construction of the project. Similarly, one might consider the effect of another power plant being simultaneously constructed within 50 miles of the project. Among the 13 sample sites there are cases in which the power plant was the first one to be constructed in the area and cases in which as many as five other units had already been constructed in the area. Likewise, it is possible to observe instances in which other nuclear plants were being built in the same general area, as well as instances in which no other projects were currently being built.

6. Utilities and Construction Contractors

Both public and private utilities were included in our sample. In addition, the sample captured variation in construction contract arrangements. The sample included sites in which the utility hired a prime

contractor. Also included were sites in which the utility was the prime contractor, including cases in which the utility hired subcontractors, as well as cases in which the utility hired construction workers directly. Another situation which was represented in our sample is the case in which the utility retained its own construction workforce.

7. Extent of Unionization

Variation in the extent of construction worker unionization is likely to affect the variables of interest in our study. Through sample sites in the Northeast and the Midwest we included areas with the strongest construction unions, and through sites in the South we included areas in which union activity is relatively weak. The sample also contained non-union sites, thereby capturing the full range of variation that one might expect to observe along this important dimension.

Preparation of the Survey Data Files

Worker surveys were coded and **keypunched**.⁷ Computer files for each data set were created and edited. Since seven different survey instruments were used to collect the data, the cleaning and editing procedures were specific to each survey instrument. The editing process included the following general procedures:

- (1) checking for inconsistencies and missing values;
- (2) eliminating inconsistent responses;
- (3) inferring responses for missing values from available information;
- (4) checking for out-of-range values; and
- (5) supplying proper missing value codes.

The extent to which such cleaning and editing was necessary (or possible) depended upon the length and complexity of the questionnaire.

⁷In the case of surveys conducted by others, procedures varied. In some instances the data were already coded and keypunched and we received the data on either computer cards or magnetic tape. In other cases questionnaires had not been coded and we received copies of the survey questionnaires. One utility had already coded surveys for movers but had not coded nonmover surveys.

Since the information which was obtained from the different surveys was not identical for all sites, it was necessary to achieve comparability--to the extent possible--across surveys in our sample. This included the following tasks:

- In the case of three surveys, converting alpha place codes to numeric place codes. This involved **recoding** the current, previous, and permanent residential locations for the three different sites.
- Recoding locational codes used by others were **recoded** to make them comparable to codes used by us.
- Other response categories were **recoded** to make them comparable across all surveys (i.e., craft codes, housing types, number of children).
- The distance from the community of residence to the site was calculated for all surveys which did not request that **information**. Since this information was considered to be important to our analysis of residential location, distances were also calculated for all other sites in our sample.

SECONDARY DATA

In addition to the survey data, considerable secondary data were also obtained for this study. These data were collected from a number of different sources, including utilities and contractors, collective bargaining agreements, state agencies and various published sources. The secondary data which were collected include variables which reflect:

- income potential associated with employment at the site;
- craft-specific labor force requirements;
- availability of labor in the region;
- competing demand for labor in the region;
- population and housing availability in the region; and
- various regional and **community** characteristics.

A summary of the project characteristics and regional and community characteristic variables which were collected for the study is presented in Tables A-4 and A-5.

In this section we present a detailed discussion of the secondary data collected. This includes a discussion of the problems encountered in secondary data collection, as well as a description of major data sources and a summary of variables collected from the various sources.

TABLE A-4

A Summary of Secondary Data Collected

Project Characteristics

Variable	Period	Area	Source
1. Collective bargaining agreement provisions, by craft a. Hourly wage rate b. Overtime rate c. Fringe benefits d. Availability of travel allowance	1978	Site	Union collective bargaining agreements (union locals and utilities)
2. Location of hiring hall of the union local with jurisdiction over the project, by craft	1978	Site	Union locals
3. Quarterly pre-construction labor requirement projections, by craft	Construction period	Site	Utilities/contractors
4. Quarterly actual labor utilization, by craft	Startup to survey date	Site	Utilities/contractors
5. Quarterly overtime hours, by craft	Startup to survey date	Site	Utilities/contractors
6. Quarterly mid-construction labor requirement projections, by craft	Survey date to project completion	Site	Utilities/contractors
7. Quarterly labor requirement profiles, by craft	Construction period	Site	CLDS
8. Power plant characteristics a. Type of plant b. Size of plant (megawatts)	----	Site	Nuclear Reactors Built, Being Built or Planned in the United States as of June 30, 1978
9. Other nuclear power plant construction activity in the region a. Already completed b. Currently under construction	----	Site	Nuclear Reactors Built, Being Built or Planned in the United States as of June 30, 1978
10. Labor requirements at other power plant construction projects a. Within 50-miles of the site b. Within 120-miles of the site	Construction period	Site	CLDS

TABLE A-5

A Summary of Secondary Data Collected
Regional and Community Characteristics

Variables	Period	Area	Source
1. Land area	1975	County	<u>County and City Data Book, 1977</u>
2. Population characteristics			
a. Population	1970	County Community	<u>1970 Census of Population, Rand-McNally, Commercial Atlas and Marketing Guide</u>
	1972, 1975	County	<u>County and City Data Book, 1977</u>
	1971, 1973 1974, 1976 1977	County	<u>Current Population Reports, Series P-25 and P-26.</u>
b. Percent urban	1970	County	<u>1970 Census of Population</u>
c. Population change	1970-1975	County	<u>County and City Data Book, 1977</u>
d. Net migration	1970-1975	County	<u>County and City Data Book, 1977</u>
3. Total employment	1970	County	<u>County and City Data Book, 1977</u>
4. Civilian labor force	1970	County	<u>County and City Data Book, 1977</u>
	1971-1978	County	State employment agencies ^a
5. Unemployment rate	1970	County	<u>County and City Data Book, 1977</u>
	1971-1978	County	State employment agencies ^a

TABLE A-5 (cont.)

Variables	Period	Area	Source
6. Employment		County	<u>County Business Patterns</u>
a. Total	1970-1976		
b. Construction	1970-1976		
c. Retail trade	1969-1976		
d. Service	1969-1976		
7. Per capita income	1969-1970	County	<u>Local Area Personal Income</u>
8. Contract construction payroll	1969-1976	County	<u>County Business Patterns</u>
9. Housing availability ^b	1970	County Community	<u>1970 Census of Housing,</u>
a. Total number of housing units			
b. Total year-round housing units			
c. Year-round housing units in one-unit structures			
d. Owner-occupied units			
e. Renter-occupied units			
f. Number of mobile homes and trailers			
g. Number of vacant units			
10. Housing change	1960-1970	County	<u>County and City Data Book, 1977</u>
11. Number of one-person households	1970	County	<u>1970 Census of Housing</u>
12. Percent owner-occupied housing	1970	County	<u>County and City Data Book, 1977</u>
13. Housing cost ^b	1970	County Community	<u>County and City Data Book, 1977;</u> <u>1970 Census of Housing</u>
a. Median value of owner-occupied housing			
b. Median rent			
14. Distance to site	----	Community	State highway maps

^aData not available from all states for all years.

^bHousing information was available only for communities with 1000 or more inhabitants.

Problems Encountered in Secondary Data Collection

As in any major data collection effort, numerous problems were encountered in the identification of possible data sources and in the specification of variables to be collected. Perhaps the overriding problem in the collection of these secondary data was the need to obtain **comparable** data for all sites included in the study. Considerable effort was devoted to determining the availability of secondary data from various local data sources. Visits were made to a number of state, regional, county, and city offices in an attempt to obtain information about population, employment, housing, and public services in the region surrounding each construction site. A number of publications were identified as sources of some of the necessary information. Publications which we obtained include population data books, unemployment figures, planning reports, and Chamber of Commerce **publications**. However, the amount of information available from local sources varied considerably from site to site. In general, those sites which were located near large metropolitan areas had much more data available than those sites located in more rural areas.

In addition to the wide variation in the availability of data across sites, these local data sources often differed with respect to the definitions of variables reported. Often variables reported were similar, but not identical, for different sites. Or, different variables were reported in different years for the same site. For example, housing availability in one year was reported as "total housing units available" and in another year was reported as "vacancy rate."

Problems regarding the consistency of variable definitions also extended to the labor requirement data which were obtained from utilities and contractors. Some utilities reported employment as average number of men per quarter, whereas in the case of other utilities employment was reported in terms of total number of man-hours. Some utilities provided quarterly data, while others provided monthly data. In order to use these data it was first necessary for us to convert the variables to the same units to achieve comparability across sites. In some instances sufficient information was available for us to do this. In other cases

these data could not be made comparable. Thus, the problem of comparability of data across sites made local data sources of limited value for the purpose of this study.

The construction of a nuclear power plant does not occur at a single point in time, but rather extends over a period of several years. As a result, another problem which we encountered in secondary data collection was the identification of the appropriate year or years for which the data were to be obtained. However, examination of potential data sources revealed that in this respect one is again limited by the availability of data. Considerable data are available in census publications. Thus, much more information was available for 1970 than for other years. In some cases, such as with respect to housing data, recent information was rather difficult to obtain. In other cases data were not readily available prior to 1970. Since project construction extends over a rather long period of time; the choice of appropriate years for data collection was not straightforward. In most cases we made an attempt to obtain data for each year from 1970 through 1978. With the exception of only one or two projects, this included the entire construction period (i .e., from the year construction began through the year of the latest survey).

An additional factor which created problems in data collection was that often data were not available at the desired level of disaggregation. Much of the secondary data required for this study were desired at the craft level. In certain cases, such as variables reflecting income potential, labor requirements, and competing demand for labor, data were available for various construction crafts. However, in other cases, such as the availability of labor in the region, craft-specific variables were more difficult to obtain.

Finally, in secondary data collection we were restricted with respect to the regions for which data are reported. Data for small areas surrounding the construction site were difficult, if not impossible, to obtain. Data are more commonly reported at the county level. For the purpose of secondary data collection, two different areas--termed the local area and the region--were defined. We defined the local area to include the county in which the site was located plus any other county which contained a significant portion of the land area within 15 highway

miles of the project (i.e., 30 percent or more). In all cases the local area included only one or two counties. A larger region was also identified for each site. We defined the region to include all counties of which half or more of the total land area was within a 50-mile radius of the site. Data were collected at the county level, since most data are reported at this level of aggregation, and variables were computed for the local area and region of each site based on these county data.⁸

Major Data Sources

Numerous sources were examined in an effort to obtain the necessary data. Since the 13 construction sites included in our study are located in six different states, the need to obtain consistent data for all sites often restricted the data collection effort. As mentioned earlier, local data sources were of limited value for the purpose of this study. Thus, whenever possible we obtained data from federal agencies and publications to allow for more inter-regional comparisons. The major sources of these secondary data include utilities and contractors, the Construction Labor Demand System, collective bargaining agreements, state employment agencies, and other published sources. A brief description of each of these data sources and the types of data obtained from them is presented below.

1. Utilities and Contractors

The utility, or the prime contractor in the case of some sites, was identified as a likely source of information regarding the labor requirements associated with power plant construction. Various data were requested from each utility or prime contractor, including (1) quarterly labor requirement projections by craft which were made prior to project construction; (2) quarterly actual labor requirements by craft which had been expended to date; and (3) quarterly labor requirement projections by craft for the remainder of the construction period. We made an attempt

⁸Data were collected for a total of 138 counties which includes 18 counties in the local impact area of the sites in our sample. Because of the close proximity of some of the sites in our sample, some counties are located in the region of more than one site.

to obtain these data from the utility or prime contractor at each of the 13 sites included in the study.

Unfortunately, there was some difficulty in obtaining these data from all sites, making these data of limited value for the purpose of this study. The problem was most serious in the case of pre-construction projections. In several cases, these projections were made more than ten years prior to the request, and consequently, these data were not readily available for all sites. In other cases, pre-construction projections were not disaggregated by craft or were available only on an annual basis. Moreover, as a result of delays in the construction schedule, those projections which were available were very poor indications of the actual utilization of labor.

We did obtain actual craft-specific manpower requirements which had been expended to date from utilities or contractors at all sites. Also, with the exception of only two sites, recent labor requirement projections for the remainder of the construction period were obtained for each site. However, differences in the way in which utilities provided these manpower requirement data required that the figures be made comparable for all sites. Monthly data, if provided, were aggregated to quarterly data. In most cases data were provided as average number of men per quarter. In other cases, however, total numbers of man-hours per quarter were obtained. In these instances, the average number of men was computed by dividing the total number of man-hours by the constant 520 (8 hours per day x 65 working days per quarter).

A comparison of the actual labor requirement profile and recent projections of employment for the remaining construction period provided an indication of overall stage of project completion at the time of the survey (*i.e.*, surveys were classified as prepeak, peak or **postpeak** based on increasing, constant or decreasing labor requirements). However, failure to obtain accurate and comparable labor requirement data from all sites led us to the search for alternative sources of labor requirement variables.

2. Construction Labor Demand System

The Construction Labor Demand System was identified as an alternate source of labor requirement data for all 13 sites included in this

study. The Construction Labor Demand System (CLDS) is a Department of Labor program for estimating on-site labor requirements for the construction of current, planned, or forecasted energy development projects in the United States. The CLDS data provide estimated manpower requirements associated with any construction project by month and year for 29 construction craft groups. These estimated manpower requirements are based upon typical manpower utilization for the size and type of project, and are updated on a regular basis using information regarding the actual utilization of labor as provided by utilities.

We obtained monthly craft-specific labor requirements from the CLDS for all 13 nuclear power plant construction projects included in the study. Based upon these data, quarterly labor requirement profiles were constructed for seven major construction crafts at each construction site. We then used these craft-specific labor requirement profiles to derive several labor requirement variables in an attempt to capture differences in the nature of the **demand** for labor for various craft groups (i.e., total number of man-hours projected, peak employment, duration of peak employment). Additional labor requirement variables were defined in an effort to capture differences in the relative attractiveness associated with employment at the construction site (i.e., the expected continuity of employment, the expected duration of employment, the expected growth of employment opportunities at the time of the survey).

In addition, we obtained monthly craft-specific labor requirements for all other power plant construction projects (nuclear as well as non-nuclear) simultaneously under construction within a 120-mile radius of each site. These data were obtained in an attempt to capture the competing demand for labor in the area surrounding the construction site. Annual labor requirements for each craft group at all other competing construction projects were computed based upon the CLDS data. We then used these data to define variables reflecting the concurrent demand for labor within a 50-mile and a 120-mile radius of the site, as well as variables reflecting the change in the concurrent demand for labor over the period of construction.

3. Collective Bargaining Agreements

Collective bargaining agreements were obtained for all major construction crafts for the union locals with jurisdiction over each **proj-**

ect. There is considerable variation in the types of provisions contained in collective bargaining agreements; however, agreements typically include provisions specifying craft and territorial jurisdictions, rate of compensation, union referral and hiring practices, normal work hours, holidays, and various working conditions. Many provisions, such as union referral and hiring practices, are difficult to quantify and therefore could not be included in the analysis. The collective bargaining agreements were useful in providing several variables which reflect the income potential associated with employment at a particular site for each craft group. The income potential variables which we extracted from the collective bargaining agreements include: (a) hourly wage rate; (b) overtime wage rate; (c) value of fringe benefits paid per hour worked; and (d) inclusion of a transportation allowance. In addition, we computed the distance from the construction site to the hiring hall of the union local with jurisdiction over the project for each craft at each site.

4. State Employment Agencies

Considerable effort was devoted to obtaining data regarding the availability of labor within commuting distance of the construction site. Union locals are, of course, the most logical source of such data. Unfortunately, unions are often rather reluctant to provide information regarding union membership and, as a result, it was necessary to pursue alternate sources of these data. While population could be used as a proxy for the availability of labor, information regarding the size of the civilian labor force and the unemployment rate were viewed as preferable variables. Indeed, perhaps even more desirable for this particular study are data reflecting the size of the construction labor force and the construction unemployment rate.

Unemployment rates were not available at the county level from federal sources for the years required. Therefore, we contacted various state agencies (i.e., Department of Labor, Employment Service, Department of Employment Security) in an attempt to obtain data regarding the size of the civilian labor force and unemployment rates for counties surrounding the construction site over the period of construction. Information for 1970 was obtained from census data. With very few exceptions, state employment agencies were able to provide this information for the period

1971 through 1978. Unemployment rates by industry, however, were not available at the county level. Therefore, we estimated the construction unemployment rate from the overall unemployment rate based upon a relationship derived from data at the state level.⁹ Overall and construction unemployment rates for the local area and the region were calculated for each year as a weighted average of the respective counties.

5. Other Published Sources

The regional characteristic variables were obtained from a variety of published sources. Population data (i.e., 1970 population, population estimates for the years 1971 through 1978, population change between 1970 and 1975) and housing data (i.e., total number of housing units, number of mobile homes, number of vacant units, percent owner-occupied units) were obtained from various census publications.¹⁰ In addition, we obtained the 1970 population of communities surrounding each site and computed the distance of each community to the construction site.¹¹ Total employment, retail and service employment, construction employment, and first quarter contract construction payroll were obtained from the County Business patterns.¹² Per capita income was obtained from the Local Area Personal Income.¹³ Data were collected at the county level

⁹We used ordinary least squares regression to estimate the relationship between the construction unemployment rate and the overall unemployment rate using data at the state level (excluding Alaska) for the years from 1971 through 1976. We then used this estimated equation to predict construction unemployment rates for the local area and region for each site as a function of the overall unemployment rates for the respective areas.

¹⁰U.S. Bureau of the Census, Census of Population: 1970, Vol. I, Characteristics of the Population; U.S. Bureau of the Census, Census of Housing: 1970, Vol. I, Housing Characteristics for States, Cities, and Counties; U.S. Bureau of the Census. Current Population Reports, Series P-25 and P-26; U.S. Bureau of the census, County and City Data Book, 1977.

¹¹U.S. Bureau of the Census, Census of Population, Op. cit.; Rand-McNally, Commercial Atlas and Marketing Guide, 1979.

¹²U.S. Bureau of the Census, County Business Patterns.

¹³Department of Commerce, Bureau of Economic Analysis, Local Area Personal Income.

and aggregated for the local area and region. Housing variables, however, were computed only for the local area.

Other data sources which were used in this study include Nuclear Reactors Built, Being Built, or Planned in the United States as of June 30, 1978 and the Inventory of Power Plants in the United states.¹⁴

These documents were used to obtain information regarding the type and size of the units under construction and the existence of other power plan construction projects already built, or under construction, in the region.

¹⁴Nuclear Reactors Built, Being Built, or Planned in the United States as of June 30, 1978 (Oak Ridge: DOE Technical Information Center, 1978); Inventory of Power Plants in the United States, U.S. Department of Energy, Office of Utility Project Operations, December, 1977.

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Survey Instrument for Surveys 1.0, 2.0, 8.0 and 9.4

1. WHAT IS YOUR OCCUPATION? (Please check the **one** box which best **describes** your job)
01 ☐ Boilermaker	08 ☐ Laborer	15 ☐ Clerical
02 ☐ Bricklayer	09 ☐ Millwright	16 ☐ Engineer/Technician
03 ☐ Carpenter	10 ☐ Operating Engineer	17 ☐ Inspector
04 ☐ Cement Mason	11 ☐ Painter	18 ☐ Management
05 ☐ Electrician	12 ☐ Pipe/Steamfitter	19 ☐ Security
06 ☐ Insulator/Asbestos Worker	13 ☐ Sheetmetal Worker	20 ☐ Other (describe: _____)
07 ☐ Ironworker	14 ☐ Teamster	
2. WHERE DO YOU LIVE DURING THE WORK WEEK? _____
(city or town) (state) (zip)
3. WHERE IS **THIS** RESIDENCE LOCATED? 1 ☐ Inside City or Town Limits
2 ☐ Outside City or Town Limits
4. WHICH ONE OF THE FOLLOWING BEST DESCRIBES THE RESIDENCE WHERE YOU LIVE DURING THE WORK WEEK?
1 ☐ Rented Single Family House	4 ☐ Owned Single Family House	7 ☐ Hotel/Motel
2 ☐ Rented Apartment or Duplex	5 ☐ Owned Apartment or Duplex	8 ☐ Rooming House
3 ☐ Rented Mobile Home	6 ☐ Owned Mobile Home	9 ☐ Other (describe: _____)
5. HOW MUCH DO YOU PAY EACH MONTH FOR THIS RESIDENCE **IN RENT OR MORTGAGE**? (Including lot rental for mobile home)
1 ☐ No Cash Payment	3 ☐ \$100 to \$149	5 ☐ \$200 to \$249
2 ☐ \$1 to \$99	4 ☐ \$150 to \$199	6 ☐ \$250 to \$299
		7 ☐ \$300 or more
6. HOW MANY BEDROOMS DOES THIS RESIDENCE HAVE? _____
7. WHICH OF THE FOLLOWING FACTORS WERE THE MOST IMPORTANT IN CHOOSING THIS RESIDENCE? (Check all that apply)
☐ Close to Work	☐ Shopping/Services Available Nearby
☐ Low Taxes	☐ Recreational Opportunities
☐ Cost of Housing	☐ Overall Community Attractiveness
☐ Housing Availability	☐ Other (describe: _____)
☐ Quality or Location of Schools	
8. HOW FAR IS **THIS** RESIDENCE FROM THE JOB-SITE? In Miles _____ In Minutes _____
9. HOW DO YOU USUALLY GET TO WORK?
1 ☐ Drive Alone	3 ☐ Drive in Union or Project Arranged Carpool
2 ☐ Drive in Personally Arranged Carpool	4 ☐ Other (describe: _____)
10. DID YOU MOVE TO **THIS** RESIDENCE TO WORK **ON** YOUR JOB AT **THIS** SITE? 1 ☐ Yes 2 ☐ No
- IF YES, (A)** WHERE DID YOU LIVE BEFORE THIS JOB? _____
(city or town) (state) (zip)
- (B)** DID YOU OWN YOUR FORMER RESIDENCE? 1 ☐ Yes 2 ☐ No
- (C)** DO YOU STILL OWN THAT RESIDENCE? 1 ☐ Yes 2 ☐ No
11. HOW MANY TIMES IN THE PAST **FIVE** YEARS HAVE YOU MOVED TO A NEW TOWN TO TAKE A NEW JOB? _____

-2-

12. DO YOU PLAN TO REMAIN IN THIS TOWN OR IMMEDIATE AREA AT LEAST AS LONG AS ACCEPTABLE EMPLOYMENT IS AVAILABLE AT THIS JOB SITE? 1 ☐ Yes 2 ☒ No
13. DO YOU PLAN TO REMAIN IN THIS TOWN OR IMMEDIATE AREA BEYOND COMPLETION OF THIS PROJECT IF ACCEPTABLE EMPLOYMENT IS AVAILABLE IN THE AREA? 1 ☐ Yes 2 ☐ No
14. DO YOU MAINTAIN A PERMANENT RESIDENCE IN ADDITION TO THE RESIDENCE IN WHICH YOU **LIVE** DURING THE WORK WEEK? 1 ☐ Yes 2 ☐ No
- IF YES. (A) WHERE IS THIS RESIDENCE LOCATED? _____
(city or town) (state) (zip)
(B) HOW MANY TIMES A MONTH (on **average**) DO YOU TRAVEL TO THIS RESIDENCE? _____
15. WHAT IS YOUR MARITAL STATUS? 1 ☐ Married 2 ☐ Single, Separated, Divorced, Widowed
- IF MARRIED. (A) IS YOUR SPOUSE CURRENTLY EMPLOYED? 1 ☐ Yes 2 ☒ No
(B) IF YOUR SPOUSE IS UNEMPLOYED, IS SHE /HE LOOKING FOR WORK? 1 ☐ Yes 2 ☐ No
16. HOW MANY CHILDREN DO YOU HAVE IN THE FOLLOWING AGE GROUPS? (Write in "0" if None)
(a) 0-4 Years (preschool) _____ (c) 13-18 Years (Grades 7-12) _____
(b) 5-12 Years (Grades K-6) _____ (d) Over 18 Years of age _____
17. WITH WHOM DO YOU **LIVE** DURING THE WORK WEEK?
1 ☐ Live Alone 3 ☐ Roommate (s) - How many? _____
2 ☐ Spouse **and/or** Dependents 4 ☐ Other
IF NOT LIVING WITH YOUR SPOUSE AND DEPENDENTS, DO YOU INTEND TO LOCATE THEM HERE?
1 ☐ Yes 2 ☐ No 3 ☐ Have No Family
18. SEX: 1 ☐ Male 2 ☒ Female
19. AGE: _____
20. YEARS OF SCHOOL COMPLETED: _____
21. WHAT IS YOUR TOTAL ANNUAL FAMILY INCOME FROM ALL SOURCES (**before taxes**)? (Check the box beside the category which best describes your income)
1 ☐ Less than \$15,000 3 ☐ \$20,000 - \$24,999 5 ☐ \$30,000 or more
2 ☐ \$15,000 - \$19,999 4 ☐ \$25,000 - \$29,999
22. ARE YOU A MEMBER OF A UNION? 1 ☐ Yes 2 ☐ No
- IF YES. (A) HOW LONG (in months and **years**) HAVE YOU BEEN A MEMBER OF THE UNION LOCAL WITH JURISDICTION OVER THIS PROJECT: (Place a "0" in the blank if you have not transferred your membership to this local.) _____
(Years) (Months)
- (B) DO YOU BELONG TO THE PREFERRED UNION **HIRING** HALL GROUP FOR JOB REFERRAL? 1 ☐ Yes 2 ☐ No
- (C) WERE YOU **INF** OF **EM** ON THIS PROJECT BY THE **SINI** **EN** OF EITHER THIS LOCAL OR YOUR PREVIOUS UNION LOCAL? 1 ☐ Yes 2 ☐ No

Thank you for Your Cooperation!

Survey Instrument for Surveys 3.0, 4.0, and 12.4

1. Your Employer's Name _____
2. Your age _____
3. Are you (please check) ☐ single ☐ married ☐ separated or divorced
4. If married, number in your family (including self) _____
5. Number of family members living with you (including self) _____
6. Ages of all your children _____, _____, _____, _____, _____, _____, _____
7. Your Occupation (check one):

01 ☐ Boilermaker	06 ☐ Bricklayer	11 ☐ Clerical	15 ☐ Carpenter
02 ☐ Cement Mason	07 ☐ Electrician	12 ☐ Insulator	16 ☐ Iron Worker
03 ☐ Laborer	08 ☐ Millwright	13 ☐ Oper. Engr.	17 ☐ Painter
04 ☐ Pipefitter	09 ☐ Plumber	14 ☐ Security	18 ☐ Supervisor
05 ☐ Teamster	10 ☐ Other		
8. How long have you worked at this job site? _____ years _____ months
9. How long do you expect to be at this job (from today)? _____ years _____ months
10. Where do you live during the work week? _____
city or town state
11. Distance from the job site _____ (miles)
12. Average one-way driving time _____ (minutes)
13. Is this residence ☐ inside city limits ☐ outside city limits ☐ do not know?
14. How long have you lived at this residence? _____ years _____ months
15. Did you move to this residence because of your job at this site? ☐ Yes ☐ No
16. If yes, from where did you move? _____
city or town state
17. What type of residence is this? ☐ single family-owned ☐ single family-rented
rental apartment ☐ hotel/motel ☐ mobile home ☐ rooming house
18. Do you share this residence with anyone who is NOT a member of your family?
Yes ☐ No ☐
19. Are any of those you share a residence with employed at this job site? ☐ Yes ☐ No
20. If yes, how many? _____
21. How do you most often get to work? ☐ drive alone ☐ drive in carpool ☐ other
number in pool
22. Do you maintain a primary residence besides the one listed above? ☐ Yes ☐ No
IF YES, ANSWER REMAINING QUESTIONS--IF NO, STOP HERE
23. If Yes, where is it located? _____
city or town state
24. Approximate distance from the job site? _____ miles
25. Number of family members living at this residence? _____
26. What type of residence is this? ☐ single family-owned ☐ single family-rented
rental apartment ☐ mobile home ☐ other
27. How often do you travel to and from this residence? ☐ on weekends ☐ more often
every other weekend ☐ other _____
28. How long have you maintained this residence? _____ years _____ months
29. Will you move back to this residence when your job here is completed? ☐ Yes ☐ No

THANKS FOR YOUR COOPERATION

Survey Instrument for Survey 5.1

Personal Characteristics

2. Marital Status (**circle one**): Single Married Divorced/Separated Widow(er)
3. Age: _____
4. Current Address: _____
 City State County

 Township
5. I currently live: _____ inside city or town limits
 _____ in a developed area outside city limits
 _____ in a rural area
6. What was your last employment before working at ***** Nuclear Station?
_____ Other Duke employment	_____ Construction or Manufacturing
_____ Construction (other than Duke employment)	_____ Another nuclear station
_____ Manufacturing	
_____ Other employment (self-employed, trade, sales, etc.)	
_____ Unemployed more than three months	
_____ Other (school, military service, unable to work, etc.)	
_____ School	
_____ Military service	

Have you moved since you were employed for ***** Nuclear Station operation?

 Yes No Yes, Moved Across Country

If **NO**, please go to Question #10.

If **YES**, please answer Questions A through D below also.

- 8.1 What was your address before you moved:

City	State	County
Township		

- 9.1 How many people currently live with you at your new location? _____
- 9.2 How many children living with you at your new location are:
- _____ Not old enough to go to school
- _____ Going to elementary, junior high, or high school
- _____ Living at home and going to college or technical school
- _____ Living at home and working

9.3 Why did you choose your new location:

☐ Close to work	☐ Quality and location of schools
☐ Low taxes	☐ Good recreation available
☐ Cost of housing	☐ Good shopping facilities
☐ Availability of housing	☐ Other (please list) _____
☐ More desirable area or housing	

9.4 Will you move when you finish working on this project? ☐ Yes ☐ No

10. How do you normally get to work?

- ☐ Your own car
- ☐ Carpool
- ☐ Other (please list) _____
- ☐ Motorcycle

11. How many miles would you have to drive to get to work from your residence? _____

12. Current place of residence:

- ☐ A house
- ☐ An apartment or duplex
- ☐ Mobile home or trailer
- ☐ Other (please list) _____

13. Which of the below applies to you?

☐ I RENT MY HOME AND I PAY:	☐ I OWN MY OWN HOME. IF I SOLD IT, I WOULD PROBABLY GET
☐ Less than \$50.00 per month	☐ Less than \$15,000
☐ \$50.00 to \$75.00 per month	☐ \$15,000 to \$20,000
☐ \$75.01 to \$125.00 per month	☐ \$20,000 to \$30,000
☐ \$125.01 to \$175.00 per month	☐ \$30,000 to \$40,000
☐ \$175.01 to \$200.00 per month	☐ More than \$40,000
☐ \$200.01 to \$250.00 per month	
☐ More than \$250.00 per month	

14. Plant Code _____

Survey Instrument for Surveys 5.2, 6.0 and 7.0

SURVEY OF THE CONSTRUCTION FORCE AT ***** NUCLEAR STATION

(Please do NOT sign your name.)

1. What is your age? ____
2. What is your current address, where you **normally** stay during the week?

City State County
3. What was your last employment before coming to *****?
____ Other Duke employment ____ Construction (not. with Duke)
____ Manufacturing ____ Unemployed ____ Other
4. Have you moved since being employed to work at *****? ____ Yes ____ No
(If No, go to question 9. If Yes, go to question 5.)
5. What was your address before you moved?

City State County
6. How many people currently live with you at your new location? ____
7. How many children currently living with you are:
Not old enough to go to school? ____
Going to elementary, junior high, or high school? ____
8. Why did you choose your new location? List in order (1, 2, 3, etc.) the reasons that apply to you.
Close to work. ____ Low taxes. ____ Cost of housing.
Availability of housing Schools. ____ Recreation.
____ Other (please list).
9. How many miles do you drive one way each day to work? ____
10. What type of residence do you normally stay in during the week?
House. Apartment. Mobile home. Other.
11. Is your local residence a full-time residence (7 days a week)? ____ Yes ____ No
12. Are you in a car pool? ____ Yes No

Thank you for completing this questionnaire. The survey will aid in licensing future projects.

Survey Instrument for Surveys 9.1, 9.2, 9.3,
10.3, 11.3, 11.4, 12.1, 12.2, 12.3, 13.1, 13.2, 13.3 and 13.4

SURVEY OF CONSTRUCTION PROJECT IMPACT

Large construction projects create a need for more housing and schools near the construction site. You are requested to provide information for a TVA survey to find out more about these needs. Your cooperation in filling out the appropriate parts of this form will be appreciated and the information given will be kept completely confidential. Please return the form to the person who handed it to you.

1. Name _____ Age _____
Job Title _____ Man No. _____
Annual _____ Trades and Labor _____
2. Where did you live before beginning work on this project?
City _____ State _____
3. Where are you living now?
City _____ State _____

CONTINUE WITH THE QUESTIONNAIRE ONLY IF YOU ANSWERED 2 AND 3 WITH DIFFERENT ANSWERS

Please check the item which applies to your case.

4. I am living in (a) a boarding room, (b) an apartment, (c) a trailer _____,
(d) a house _____.
5. I (a) own, (b) rent _____.
6. I am living in the project area (a) by myself, (b) with roommates _____,
(c) with my family _____.

ANSWER THE NEXT QUESTION ONLY IF YOU ARE LIVING IN THE PROJECT AREA WITH YOUR FAMILY

7. I have _____ children living with me. Of these, there are (a) _____ in grade school, (b) _____ in high school, (c) _____ in college.

Survey Instrument for Surveys 10.1, 10.2, 11.1 and 11.2

SURVEY OF CONSTRUCTION PROJECT IMPACT

Large construction projects create a need for more housing and schools near the construction site. You are requested to provide information for a TVA survey to find out more about these needs. Your cooperation in filling out the appropriate parts of this form will be appreciated and the information given will be kept completely confidential. Please return the form to the person who handed it to you.

1. Name _____ Age _____
Job Title _____ Man No. _____
Annual _____ Trades and Labor _____
2. Where did you live before beginning work on this project?
City _____ State _____
3. Where are you living now?
City _____ State _____

CONTINUE WITH THE QUESTIONNAIRE ONLY IF YOU ANSWERED 2 AND 3 WITH DIFFERENT ANSWERS

Please check the item which applies to your case.

4. Are you living in (a) boarding room, (b) apartment, (c) trailer ____, (d) house ____?
5. Do you (a) rent ____ or (b) own ____?
6. Are you living in the project area (a) by yourself, (b) with roommates ____, or (c) with your family ?

ANSWER THE NEXT QUESTION ONLY IF YOU ARE LIVING IN THE PROJECT AREA WITH YOUR FAMILY

7. How many children are living with you ____?
Of these, how many are in (a) grade school, (b) high school ____, (c) college ____?
8. Would you prefer to live in another type of housing in this project area?
Yes ____ No ____
If yes, what type of housing would you prefer?
 9. House (a) to rent ____ or (b) buy ____
 10. Apartment
 11. Trailer (a) rent ____ or (b) buy ____
 12. Boarding room ____
13. What prevents you from living in the type of housing you prefer in the area?
 - (a) Not available ____
 - (b) Available but costs too much ____
 - (c) Available but too far from work ____
 - (d) Other reason ____

APPENDIX B

CONSTRUCTION WORKER SURVEYS: A MEANS FOR SUCCESSFUL IMPLEMENTATION

APPENDIX B

CONSTRUCTION WORKER SURVEYS: A MEANS FOR SUCCESSFUL IMPLEMENTATION

The ever-increasing demand for energy has created a need to construct large power plants, including nuclear power stations. These large projects require a relatively long construction phase--approximately five to ten years--that provides employment for 2,000 to 4,000 workers during its peak. Typically, these large power projects have been located in rural surroundings, at some distance from areas with large labor pools. The employment opportunities created by these construction projects often bring a sudden influx of workers and their families to the small communities near the construction site.

The problem of estimating the socioeconomic impacts of immigrating workers on the local communities surrounding a construction site is being addressed with increasing frequency.¹ Previous forecasts of population growth and residential location related to nuclear power plant construction have rarely been accurate.² They have suffered from a lack of information regarding the immigrating workers and their choices of residential location. The need for more accurate information to serve as a basis for making future predictions and for monitoring socioeconomic assessments is quite clear. This need has been recognized; recently, several attempts have been made to conduct construction worker surveys at a number of nuclear power plant construction sites throughout the United States.

¹The National Environmental Policy Act requires that a socioeconomic impact statement be prepared as part of the licensing process and that these impacts be monitored during the period of construction. Moreover, the impact assessments are used as a basis for compensating communities for adverse impacts due to the construction of a power plant.

²For an evaluation of socioeconomic impact studies, see Socioeconomic Impacts: Nuclear Power Station Siting, Policy Research Associates, State College, PA, 1977.

Many of the past attempts at conducting surveys of construction workers have had only limited success. This can, in part, be explained by the unique nature of the survey problems encountered at a large construction site. First, the construction workforce is generally transient; work is often temporary and there may be a high turnover from one week to the next. Thus, the number of workers is not constant, but rather varies from day to day. Second, the workforce is quite large and workers are dispersed over a very large construction site. Finally, the names and addresses of the workers are not usually available to define the population in question. Consequently, to identify a "representative sample" of construction workers at a site is virtually impossible.

To effectively implement a construction worker survey--in order to gain the cooperation of the individual construction workers--first it is necessary to gain the cooperation of a number of individuals and groups at a construction site. These may include the utility, prime contractor, project manager, subcontractors, foremen, and unions. An understanding of the employment relationships and union arrangements at construction sites is essential to the success of conducting a survey of construction workers.

We successfully conducted worker surveys at four different nuclear power plant construction sites. The task, however, required an extensive use of time and resources. Our effort would have been substantially less if the problems associated with such surveys and the experiences of previous researchers in implementing these surveys had been documented and available to us. Recognition of this need has led us to write this paper.

We will systematically present the problems associated with conducting construction worker surveys and suggest possible methods to solve these problems. The discussion is divided into six sections: (1) Pre-survey Groundwork; (2) Sampling Issues; (3) Viable Methods of Survey Administration; (4) Response Rate and Follow-up; (5) Development of the Survey Instrument; and (6) Other Issues. We discuss each of these in turn below.

PRE-SURVEY GROUNDWORK

It is usually not possible to identify the construction workers by name or address. This fact immediately limits the options available to

the researcher for conducting the survey. Specifically, the survey has to be conducted at the work site. The cooperation and involvement of a number of key individuals at a site is necessary, therefore, to systematically establish contact with the workers. Achieving this cooperation, however, is not simple. Employment arrangements at large power plant construction projects are governed by a hierarchy of employment and union relationships. Although these employment arrangements might vary from site to site, in general, the hierarchy is of the form illustrated in Table B-1.

The Employment Hierarchy

Typically, the utility has a prime construction contractor on a project who has the overall construction responsibility on the site. Several specific construction activities on the site are contracted out. Other jobs are undertaken by the prime contractor without intermediary subcontractors. In this latter case, the supervisors and workers are hired directly by the prime contractor. In the former, the subcontractors are the immediate employers of construction workers at a site. The workers usually work in small groups, typically consisting of five to twenty persons; each group is supervised by a foreman or supervisor.

There are, of course, exceptions to the hierarchy described here. In some cases, the utility acts as its own prime contractor and has several subcontractors on the project. Alternatively, subcontractors are confined only to very specialized jobs and the utility hires the workers directly to perform the various construction jobs on the project. Some utilities and prime contractors have construction workers on their regular staff and they do not hire workers on an "as required" basis from local pools of union or nonunion workers.

On construction sites that are covered by collective bargaining agreements, the unions also play a significant role. The prime contractor and subcontractors get their workers through the union hiring halls of the various locals. Collective bargaining agreements sometimes stipulate that foremen for various jobs must also be hired through the union halls. Moreover, each union local has a union job steward at the site to assure that the provisions of the collective bargaining agreements are

TABLE B-1

HIERARCHY OF EMPLOYMENT RELATIONSHIPS AT CONSTRUCTION SITES

implemented. These provisions often give the unions an important say in terms of what is requested of workers on the job.

• • Obtaining the Necessary Cooperation

The multiplicity of contractors, subcontractors, and construction trades each with its own local union makes gaining cooperation from each of them a difficult task. But such cooperation is essential to the success of the survey. Further, the cooperation of these groups could be instrumental in obtaining the eventual cooperation of the workers themselves. There are several concerns that discourage all these groups from cooperating. These concerns include:

- the usefulness of the study;
- the possible use of staff and worker time to implement the survey;
- a common distrust of research findings and the potential for such findings to affect adversely the interest of the groups at the construction site; and
- a in the case of workers, an attitude of indifference towards any form of research.

Foremost to gaining the cooperation of these groups is an ability to demonstrate the usefulness of the findings of the study to everyone associated with nuclear power plant construction. This we found was best achieved through personal contact; written communication set the stage but rarely brought about outright willingness to cooperate. It will be obvious from the following discussion of methods for implementing the surveys, that the survey not only imposes a burden on the workers but also requires the use of their work time on the project. Not surprisingly, a utility and contractors will cooperate only if they see some potential benefit accruing to them from the proposed study. We found that the offer to compensate for use of worker time to complete the questionnaire, though rarely accepted by a utility, also helped to elicit their cooperation.³

³Only one of our four utilities requested reimbursement for conducting a survey at their site. For about 1,500 workers filling out a 15-minute questionnaire on the site, we were charged approximately \$8,000.

An effective approach to seeking and obtaining the cooperation of the key individuals is to start at the top and work down the hierarchical structure shown in Table B-1. The process requires identifying the key individual at the utility level and seeking both his explicit support for the project as well as his assistance in identifying and seeking the support of key individuals further down the employment hierarchy.

The Utility. The support of the utility and the prime contractor is likely to influence the decisions of the groups who work for them. In fact, it is unreasonable to expect cooperation from anyone else without their explicit support and involvement. **I**f the utility representative is convinced that the study is likely to be useful to the utility and is willing to say so, then obtaining the support at other levels is made considerably easier.⁴ In many cases, it might be possible to use the agency sponsoring the research to make the initial contact with the utility personnel.⁵

The Project Manager. The project manager, or a member of his staff, then becomes a key contact for meeting and seeking the cooperation of the subcontractors, supervisors, and union representatives at the site. He is also instrumental in developing an acceptable survey strategy and making the necessary arrangements to conduct the surveys. Because all the feasible methods of implementation require the supervisors to act as a link between the researcher and the worker, subcontractors and supervisors need to be involved in the development of the implementing procedures.

Other Project Staff. The procedures for contacting other members of the project staff will vary greatly depending upon the project manager. A project manager may wish to appoint an assistant to make further

⁴At each of the four sites in our study, our contact person at the utility understood the sensitivities of the construction project staff and was essential in introducing the research team to the project manager for the utility and/or the prime contractor.

⁵We were able to use the NRC to make the initial contact with the utilities; despite this, it was necessary to contact six utilities in order to get four participants.

arrangements. Some project managers will choose to involve a large number of people at this stage; others may involve only a few. The extent to which supervisors and foremen are involved varies depending upon the survey strategy selected as well as by the decisions of the project manager.

Unions. Getting unions to encourage their members to participate in the survey is perhaps the most difficult task. Unions are very independent, have a direct access to workers, and can influence worker response. **I**f they are not consulted, or are skeptical about the research to be performed, the chances of implementing the survey are remote. Furthermore, the utility and the prime contractor are eager to maintain good labor and management relations and are not likely to accept anything that might potentially jeopardize that relationship.⁶ Union job stewards at the construction sites have direct access to and influence on the workers. Workers are not likely to respond to the survey if the union stewards at the site do not encourage them to do so. Likewise, union stewards are not likely to cooperate without the approval of the business agents of their union locals.

The Building Trades Council. The task of getting the cooperation of the various crafts and separate union locals is impossible without the help of the project staff. An effective way is to use the labor management relations officer from the utility or the prime contractor to seek the assistance of the local Building Trades Council in getting individual business agents to cooperate. The local Building Trades Council is an association of construction trade unions which offers a platform to various union locals to coordinate their activities and to discuss the construction employment requirements with the major construction contractors in the area. The Building Trades Council can provide the opportunity to explain the project directly to all the union representatives at the same time and thereby save tremendous amounts of effort required to contact

⁶The influence of unions varies from site to site. It was our experience that unions commanded greater influence at sites in the Northeast compared to the South. Accordingly, it was easier to arrange surveys at the southern sites.

the unions individually. The extent to which union cooperation has to be sought should be determined in consultation with the project staff and can be expected to vary from site to site.

This pre-survey groundwork can be time consuming and may extend over a prolonged period. It is, however, extremely important and should be included in the survey planning. In our experience, careful planning of these details was perhaps the most instrumental factor in the success of our surveys.

SAMPLING ISSUES

The number of workers at a nuclear power plant construction site may vary from 500 to 4,000, depending upon the stage of project completion. Thus, one might conclude that surveying only a sample of these workers would be sufficient to test hypotheses and draw conclusions about the entire population. This is not necessarily true, however, in the case of construction worker surveys because of the transient nature of the workforce and because of the importance of subgroups of the workforce at a given site.

In the first place, it is not possible to identify easily the population of construction workers at a site. The construction workforce, as we have noted, is transient; often there is a high turnover from one week to the next. Also, workers move from one job to another and from one subcontractor to another on the site. It is therefore not possible to identify the population from which one might sample.

Furthermore, if the data will be widely used, there is a need to survey workers from all crafts represented at the site. This is true for two reasons. First, because differences across crafts are usually important to the analysis to be performed, and second, because a researcher is invariably seeking to generalize from the data at one point during the construction phase to other points during the construction phase. At any one particular time, depending upon the stage of project completion, some crafts will be represented on the site in rather small numbers. The fact that these crafts constitute a small proportion of the total workforce at the time of the survey does not reflect the relative importance of the craft during the entire phase of construction. If the purpose of the survey is to collect information that can be applied to various stages of

project completion, it is important to include adequate numbers of these smaller crafts in the sample.

These factors suggest that stratified random sampling ought to be adopted. This, however, is rather difficult because of the level of prior information required to draw a stratified sample. Typically, even the number of workers expected to be on the site at a particular time can **only** be estimated rather crudely; it is virtually impossible to obtain accurate estimates of the number of workers by craft.⁷

Since stratified or simple random sampling is usually not possible, a reasonable alternative is to conduct a census survey at the site. This situation is not as unfortunate as it might seem. On the contrary, it has the advantage of reducing the problem of bias and enabling the researcher to examine small but key groups of workers at the site. It was our experience that, in view of the special implementing arrangements for conducting the survey at a construction site, a census survey is easier and also less costly than surveying a sample of workers. This is because the viable survey administration methods that can be adopted are such that conducting a sample survey would make the procedures much more complicated. The next section on the viable methods of survey administration will clarify this point.

VIALE METHODS OF SURVEY ADMINISTRATION

Many of the standard procedures for administering surveys, such as mail surveys, telephone surveys, and personal interviews, are not viable for conducting a survey at a large construction site. The reason for this is that names, addresses, and telephone numbers generally are not available for the population of workers at the site. This is not to say that a record of names and addresses is not maintained. There are, however, two problems to obtaining them. First, there is usually no single source where an up-to-date, complete listing of names and addresses of workers at a site is maintained. Second, utilities and contractors are

⁷This information is difficult to obtain because workers from a particular craft typically work for several subcontractors. Even specialty craft subcontractors have a few workers from other crafts working for them.

not likely to release this information, even if it were available, because they deem it personal. This reluctance to release names and addresses stems from a consideration of the implications that this action might have on employer-employee relationships.

The unions could possibly be another source of this information. However, the unions are usually the most skeptical of research projects and are the least likely to cooperate. Also, using union membership lists to identify workers would exclude nonunion workers on the site from the survey.

This inability to identify the worker population considerably limits the methods that a researcher can adopt to implement the survey. Accordingly, some form of group administration is the only option to implement a survey of workers at a construction site. Options such as distributing questionnaires with paychecks, or handing out questionnaires at entry and exit points of the site seem potentially plausible but are not, in fact, workable. Such procedures, without pre-identification of individual workers, do not allow any control over completing and returning of the survey forms, and would probably yield an unacceptably low response rate.

The only procedures that are likely to work under the circumstances are those in which the questionnaires are distributed and collected in a controlled manner. These require a system by which every worker at the site can be contacted individually or in a group and the surveys administered at that time. The precise method for implementing a survey will depend upon the specific administrative practices of the construction site in question.

After numerous discussions with utility and project staff at the various sites and after evaluating the procedures used by various other groups to administer similar surveys, as well as the response rates achieved in these survey efforts, we identified three viable options for conducting the surveys. These options include 1) the safety meeting option, 2) the supervisor option, and 3) the paycheck distribution option. Each of these three options is described in detail below.

The Safety Meeting Option

The first option takes advantage of the safety meetings that are required to be held at regular intervals at nuclear power plant **construc-**

tion sites.⁸ At these meetings, workers meet in small groups to discuss questions of safety at the site under the supervision of a foreman or a supervisor. These meetings are therefore a convenient place to conduct the survey.

The survey forms can be distributed, completed and collected at the meeting itself. This option requires that the regular safety meeting be extended by 10 or 15 minutes. Meeting locations and number of workers at each meeting can be predetermined. Arrangements can be made to deliver the required number of questionnaires and to collect them at each location. At the conclusion of the safety meeting business a supervisor or the person administering the survey can briefly describe the nature of the study, be available to answer any questions, and encourage the cooperation of the workers in filling out the survey. An important feature of this procedure is that it is likely to result in a high response rate, requires no follow-up, can be closely monitored, and covers all workers present on the site.⁹

There are, however, certain conditions that are important to the feasibility of this option: foremost is the willingness of the utility personnel and/or prime contractor to extend the safety meeting for administering the questionnaire. In addition, it is important to confirm that safety meetings do indeed cover all workers and are held on regular basis. If not, bias due to omission of certain groups of workers from the survey could be inadvertently introduced.

The Supervisor Option

The second option takes advantage of the way in which work is organized at a construction site. Workers at a site are divided into small groups under a foreman and/or supervisor. In this option each supervisor

⁸At some sites safety meetings are scheduled weekly, with meetings for all crafts being held at the same time at a central location. At other sites safety meetings may be held at different times, on different days, for different groups of workers.

⁹It should be noted that safety meetings will not include office workers. Therefore, if this option is selected, it will be necessary to make special arrangements to survey office workers.

administers the survey to his workers, either individually or as a group, at some convenient time during the day. Supervisors and the number of workers in each crew can be identified in advance. Supervisors can be given the required number of questionnaires at the beginning of the day and the completed questionnaires can be collected from them at the end of the day. If a supervisor is unable to get all his workers to fill out the questionnaire that day, he can be asked to have them filled out the next day.

This permits the survey to be conducted with little or no disruption of work. For example, supervisors can use the normal breaks between work to have workers complete the questionnaire. Although this procedure does have the advantage of not disrupting work, it does require the cooperation and assistance of a large number of supervisors. Supervisors must understand the purpose of the survey and follow precise administering instructions to assure the objectivity of the survey.

This preparation can be done best if the researchers can meet with the supervisors individually or in a group.¹⁰ Despite the fact that work crews are scattered over a large area at the construction site, foremen/supervisors do meet regularly with the project staff and subcontractors. These meetings could provide access to the group of supervisors who will be used to administer the survey to workers. Such a meeting, however, may not always be possible at all sites.

The Paycheck Distribution Option

The third option is based on the use of central paycheck distribution locations at a site. At some sites, paychecks are distributed at a few central locations, with exits that can be easily manned. This allows for the contact necessary to conduct the survey effectively. This procedure involves stopping work 10 or 15 minutes early and distributing the questionnaires with workers' paychecks. Workers are asked to complete the questionnaire immediately and to return the completed questionnaire as they leave the pay area.

¹⁰A group meeting is necessary because of the number of foremen or supervisors at a site might be as many as 200. Individual contact is feasible only for those who are unable to attend the group meeting.

The viability of this option depends upon the willingness of the utility to allow workers to quit work 10 or 15 minutes early on payday, the number of payment points on the site, and the ease with which the exits from the payment points can be monitored. For this procedure to be successful, **it** is important to inform workers about the survey and to seek their cooperation before the actual survey date.

These three options are the only ones which we considered to be viable methods for effectively implementing a construction worker survey. **It** may be possible to identify other viable options, given the circumstances at a particular site, but we were unable to identify acceptable alternatives in our experience at the four sites that we surveyed.

The effectiveness of these options will vary from site to site and depend upon the arrangements that utilities and prime contractors are willing to make at a site for purposes of the survey.¹¹ For instance, safety meetings may not be scheduled regularly for all crafts and therefore may not be a feasible option at a given site. The supervisor option may be difficult because **it** requires the cooperation of a large number of individuals at a site; however, **it** may be regarded as the least disruptive to the work on the project. The paycheck distribution is perhaps the least attractive of the options we have identified, but might be considered the most convenient by the utility or the prime contractor.

A very important thing to remember is that the final choice of the method to be adopted is not completely in the hands of the researcher. The researcher must be flexible and adapt the survey strategy to the conditions and circumstances at a given construction site. **It** is, however, useful to identify several alternatives for administration of the surveys, so that various options can be discussed with the representatives of the utility and/or prime contractor and an option acceptable to the researcher and to the project staff can be identified. In general, the project staff will want to choose the option that is least disruptive to the work on the project. Utility personnel may also

¹¹The supervisor option was adopted on three of the four sites that we surveyed. The safety meeting option was selected at the fourth site.

express concern about the cost of the workers' time taken to complete the questionnaire. In some cases, reimbursement might be necessary to gain the cooperation of the utility.¹²

Once an option for survey administration has been adopted, it is important to meet with everyone who will be involved in the survey activity. (The particular individuals will depend upon the option selected.) It is crucial that these individuals recognize the importance of the project, and that they understand their specific responsibilities.

RESPONSE RATE AND FOLLOW-UP

The success of the survey effort is very dependent upon a high response rate from the workers. Careful preparation is necessary because, except perhaps for the supervisor option, there is little opportunity for follow-up.

As was mentioned in an earlier section, getting the cooperation of the workers is extremely important to achieving a high response rate. Unless the importance of the study can be conveyed, workers may be rather reluctant to complete the questionnaire. It is helpful to get the project management, unions, supervisors, and union job stewards to support the survey and encourage the workers to complete the survey instrument.

Calculating an actual response rate may also present some problems. The information necessary to calculate a response rate is merely the number of completed questionnaires and the total number of workers on the site on the day of the survey. If response rates by craft are desired, then total workers by craft on the day of the survey are also required.

This information, however, may not always be readily available. For example, it is possible that attendance is reported only on a weekly basis (as the average number of workers on site during that week) or that information by craft is not available. Arrangements should be made with the project staff to obtain the necessary information. This should be done prior to the survey date to allow sufficient time to develop an

¹²Reimbursement was an issue at only one of the four sites that we surveyed.

acceptable procedure to estimate total worker counts at the site on the day of the survey, if an exact count is not available.

DEVELOPMENT OF THE SURVEY INSTRUMENT

The development of the survey instrument is certainly of major importance in any research project. As is the case in most surveys, in developing a survey of construction workers, a trade-off must be made in terms of the amount of information that can be obtained and the length of the questionnaire. Utility personnel often expressed the opinion that the questionnaire should be limited to one page and should not take more than 10 minutes to complete.

In addition to concerns about the length of the questionnaire, objections may also be encountered regarding particular questions. For example, in our experience, the project and union representatives felt that questions regarding income and rent were too personal.¹³ Also, union representatives at one site objected to including a question about union status.

Serious objections may require deleting a question from the questionnaire. In other cases, questions may be rephrased or otherwise modified to minimize the objections. For instance, a worker may be asked to indicate rent or income within certain ranges, rather than to provide the exact amount. In addition, questions requesting information of a personal nature can be placed at the end of the questionnaire.¹⁴

An additional problem that may be encountered in surveying a worker population of this type is illiteracy. Especially among less-skilled workers such as laborers, functional illiteracy may not be **uncommon**. For this reason, the questionnaire should be kept as simple as possible.

¹³**Indeed**, analysis of our completed questionnaires did indicate that rent and income were the two questions that were most often left unanswered.

¹⁴**Also**, we included a sentence in the introduction to the questionnaire stating that the worker did not have to answer any question that he considered to be too personal.

We raise the issue of questionnaire development because the details of the survey instrument usually receive attention only after most of the groundwork has already been completed. It can be very disappointing to the researcher to have to exclude what he feels is information essential to his research.

OTHER ISSUES

Several other factors are important in assuring success of the survey effort. These factors also arise from the special nature and circumstances of the construction activities at a site.

The time that the survey is conducted could be an important factor. Construction work is often seasonal. Especially at northern sites, construction may slow down or completely stop during the winter months. Day of the week can also be important. (If the surveys are administered during the safety meeting or on payday, there is little choice in this matter.) Mondays and Fridays are generally considered to have the highest rates of absenteeism, and for this reason may not be the best days to conduct a survey. Further, Mondays and Fridays are not ideal for a number of other reasons. Mondays may not allow enough time for distributing the questionnaires to supervisors and for other survey preparations. Similarly, surveys conducted on Fridays allow no time for any follow-up activities on the next day.

If possible, it may also be desirable to avoid scheduling a survey on the day before or after a major holiday. Attendance on those days may be somewhat lower than usual. Even the weather can be a factor in the success of the survey; rain on the day of the survey can affect attendance. There is, however, no convenient solution to this problem.

We found it very helpful to prepare a brief description of the project for distribution at the many meetings that were scheduled. This description should include the purpose of the study, the nature of questions asked, and emphasize the importance of the study to everyone associated with nuclear power plant construction. Not only the key individuals of the project staff, but the workers themselves, should be informed of the survey in advance. If a regular safety meeting is held, an announcement can be made during the meeting preceding the survey. Alternatively, a brief notice describing the survey can be included with

paychecks before the survey date. Also, announcements can be printed and posted at several places around the site where workers are likely to gather. We used several of these methods successfully in the surveys we conducted.

SUMMARY

In conducting a construction worker survey, it is important to gain the cooperation of a number of individuals at the construction site. A rather complex hierarchy of employment and union relationships exists at a construction site and a researcher is confronted with the problems, not only of the workers' attitude to the survey, but also the attitudes of several other individuals. The secret to ensuring the success of the survey effort lies in obtaining the cooperation of all the key individuals at the site before the survey. Although these individuals should be closely involved in decisions regarding the procedures developed to conduct the survey, any burdens imposed upon the utility and project staff should be minimized. Costs and labor relations are paramount concerns to utility personnel and the researcher should be sensitive to their concerns.

Assuring a high response rate is, of course, the most important consideration. A survey strategy should be selected that will maximize the likelihood that a worker will return a completed questionnaire. This requires a situation in which the survey administration can be monitored. Distributing questionnaires during group meetings or distributing them to workers through their supervisors has proved to be very successful in this regard.

This paper has been a very general discussion of the problems confronted in conducting a construction worker survey. In fact, circumstances will vary considerably from site to site. Decisions should be made based upon the particular circumstances at each site. However, it is hoped that the above discussion will provide some suggestions which may be useful in approaching the problem in future research projects.

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APPENDIX C

MIGRANT PROPORTION MULTIVARIATE ANALYSIS

APPENDIX C

MIGRANT PROPORTION MULTIVARIATE ANALYSIS

This appendix presents a more detailed discussion of the migrant proportion analysis which was conducted in the multivariate analysis portion of this study. The purpose of the analysis was to explain the observed variation in craft-specific migrant proportions across the sites included in this study. The results of this analysis served as a basis for specifying procedures for forecasting migrant proportions at future nuclear power plant construction sites. The discussion is divided into three sections. The first section describes the determinants of migrant proportions at nuclear power plant construction sites. The second section describes the empirical specification and the final section describes the analysis results.

DETERMINANTS OF MIGRANT PROPORTIONS

The problem which is addressed in this study is a special case of migration. While most migration studies examine the gradual movement of people from one area to another, this study examines the rather sudden movement of workers in response to a particular employment opportunity--a situation in which employment demand far exceeds the local labor supply. Thus, this study does not examine migration in the general population, but rather focuses upon migration within the construction industry. This is an important consideration because the factors which influence the migration of workers to large construction projects differ in many respects from the factors typically considered in traditional migration studies.

Most migration models view migration as a permanent move. However, employment for construction workers is seldom permanent. Especially among more specialized crafts, workers are hired for specific jobs of a rather limited duration. As a result construction workers often must move from site to site or commute rather long distances each day to maintain steady employment.

As is true of workers in other industries, the attractiveness of an employment opportunity to a construction worker lies in the expected

income to be derived from a given move. In traditional migration studies wage rates are commonly used as measures of the relative attractiveness of employment opportunities to movers. However, because employment opportunities in construction are usually of a relatively short duration, other factors relating to the availability of employment are very important considerations. The potential of an employment opportunity for a construction worker is, to a large extent, determined by the regularity with which a worker can obtain work and the length of time over which such regular employment is available. Also important is the opportunity for overtime work. Even though the wage rate is the same for two different jobs, the income associated with them could vary considerably depending upon the continuity and duration of employment and the availability of overtime work. Thus, it is the annual income, rather than the hourly wage rate, which is the important consideration. A consideration of the craft-specific differences in the attractiveness of employment opportunities has not been included in past studies. This study will attempt to determine the importance of variables which reflect differences in the wage rates, as well as variables which reflect differences in the nature of labor requirements (i.e., expected duration and continuity of employment) in explaining the variation in migrant proportions across sites and across various craft groups.

Worker immigration is also likely to vary from site to site depending upon the characteristics of the area. If construction occurs in a relatively populated area, one might observe little migration associated with construction because the local labor supply may be able to meet the increased demand for workers. In a very rural area, on the other hand, one might observe considerable immigration. A consideration of the local availability of labor is particularly important because in the construction industry access to particular jobs is controlled by the union through the union hiring hall or work referral system. Through this system, preference is given to members of the union local with jurisdiction over the project. The hiring hall system is also used to give preference to workers based on length of seniority in the union local. Thus, very important to a study of the nature are considerations of the size of the construction labor force within commuting distance of the site and the competing demand for workers from other construction projects in the

area. However, also important are the factors which reflect the attractiveness of the area to immigrating workers. These factors might include future employment opportunities in the area and the availability of housing in nearby communities. In this study we examine the importance of factors such as the local availability of labor, competing demand for labor in the region, and various other regional characteristics in explaining the variation in craft-specific migrant proportions across sites.

EMPIRICAL SPECIFICATION

Migrant proportion was defined to be the ratio of the number of movers to the total number of workers at the site. Workers were classified as movers if they had changed their work week residence to work at the construction site. The unit of analysis for purposes of estimating these equations was workers grouped by craft. Because of major differences between construction and nonconstruction workers, as well as the factors that are likely to influence their migrant proportion at a site, two separate equations were specified and estimated. The construction worker equation included the following seven craft groups:¹

- plumbers and pipefitters;
- ironworkers
- a boilermakers;
- operating engineers;
- electricians;
- carpenters; and
- laborers and teamsters.

The nonconstruction worker equation included two groups:

- clerical workers (including security and medical/nursing staff); and
- management (all other nonconstruction workers, including managers, engineers, and supervisors).

¹We excluded workers from other crafts such as bricklayers, cement masons, sheetmetal workers, painters, and asbestos workers. This heterogeneous group of workers, however, typically constitutes less than eight percent of all workers at a nuclear power plant construction site.

Based upon theory and the results of our profile analysis we specified migrant proportions as a function of several factors. These factors can be expressed as a functional relationship of the following form:

$$(1) \text{ MPROP} = f(\text{INCPOT}, \text{LABRQ}, \text{COMPDMD}, \text{LBAVAIL}, \text{RGCHAR}, \text{CONTVAR})$$

where:

MPROP = Migrant proportion of a particular craft at a site;

INCPOT = A vector of variables reflecting the income potential associated with employment at the site;

LABRQ = A vector of variables reflecting labor requirements at the site;

COMPDMD = A vector of variables reflecting competing demand for labor in region;

LBAVAIL = A vector of variables reflecting local availability of labor in region;

RGCHAR = A vector of regional characteristic variables; and

CONTVAR = A vector of control variables.

However, for the purpose of explaining the variation in migrant proportions across surveys for various craft groups, we used ordinary least squares regression to estimate an equation of the following form:

$$(2) \quad \text{Ln} \frac{\text{MPROP}}{1-\text{MPROP}} = \alpha_1 + \alpha_2 \text{Ln INCPOT} + \alpha_3 \text{Ln LABRQ} \\ + \alpha_4 \text{Ln COMPDMD} + \alpha_5 \text{Ln LBAVAIL} \\ + \alpha_6 \text{Ln RGCHAR} + \alpha_7 \text{Ln CONTVAR} + \epsilon$$

where the terms are the same as in equation (1), except:

α s = coefficients of variables included in the equation;

ϵ = the error term; and

Ln = the natural logarithmic transformation.

Two special features of the linear relationship shown in equation (2) should be noted. First, a logit transformation was used because the values of the dependent variables, being proportions, are constrained between 0 and 1. This transformation has the effect of ensuring that the

predicted migrant proportion values will not fall outside the range of zero to one. Second, a logarithmic transformation of the explanatory variables was used to capture the non-linear relationship between the variables and migrant proportions.

Data from 21 construction worker surveys from 9 nuclear power plant sites were included in the analysis. Crafts with less than 30 workers at a site were excluded from the analysis because of the potential for large errors in estimating migrant proportions based on small numbers.² This yielded a total of 134 observations for the construction worker equation and 42 observations for the nonconstruction worker equation.

Definition of Variables

Several variables were defined to capture the influence of the explanatory factors shown in equation (2). In many instances, the specific variables included in the nonconstruction worker equation differed from those included in the construction worker equation. This was dictated by the differences in the nature of construction and nonconstruction employment, labor requirements at the site and the availability of data on nonconstruction workers. A brief discussion of each of the explanatory factors, as well as the specific variables which were considered, is presented below. The precise variable definitions are included at the end of this appendix.

1. Income Potential

Among construction workers, migration is likely to be influenced by the income potential associated with employment at a particular site. We identified four variables which reflect differences in the rate of compensation and, therefore, income potential, for construction workers. The following variables were considered:

- wage rate (WAGE);
- overtime rate (OTIME);
- fringe benefit rate (FRINGE); and
- availability of travel allowances (TALLOW).

²In addition, 3 surveys from one site were included from the analysis because data for some of the explanatory variables were not available for that site.

Due to the nature of construction employment (i.e., irregularity of employment) a number of other factors can also influence income potential for construction workers. These include factors such as continuity and duration of employment. Those variables, however, reflect differences in labor requirements associated with project construction and are included as part of our discussion of labor requirement variables.

Among nonconstruction workers, on the other hand, migrant proportions observed at a site are less likely to be associated with income potential and much more likely to be influenced by the personnel policies of utilities and engineering firms. Especially among the management group, a large number of workers are likely to be brought in by the utility or prime contractor to work on the project with only a small number being hired locally. Moreover, the nonconstruction group is a very heterogeneous group and, as a result, no typical income values could be obtained for the clerical and management groups. Thus, reflecting both the lack of adequate data and the importance of personnel policies in influencing migrant proportions, no income potential variables were included in estimating the nonconstruction equation.

2. Labor Requirements

We developed several variables in an effort to capture differences in labor requirement profiles among the different crafts at a site as well as across sites. Some variables were developed to capture the expected availability of employment at the site over the entire construction phase of the project. These variables, which include continuity and duration of employment are important because they influence the expected income of construction workers. Other variables were defined to reflect differences in overall and peak workforce requirements. Also, because of the cross-sectional nature of our data, we developed other variables to capture differences in labor requirements at the time of the survey. Specifically, the following variables were considered:

- expected continuity of employment at the site (CONT) ;
- expected growth of employment opportunities at the time of the survey (GREMP) ;
- total projected employment (TEMP) ;
- number of workers at a site at the time of the survey (NCRAFT);
- overall stage of project completion (PEAK);

- expected peak employment (NPEAK); and
- expected duration of peak employment (DPEAK).

Unfortunately, detailed labor requirement data were not available for the nonconstruction workforce. Indeed, the only variable which was available for the nonconstruction group was the number of workers on site at the time of the survey (NCRAFT). This variable was included in estimating the nonconstruction equation.

3. Competing Demand for Labor

An attempt was made to determine the competing demand for workers at other construction projects in the area. The variables which we defined to capture the concurrent demand for construction workers in the region were based upon craft-specific labor requirements of other power plant construction projects in the area.³ Distances of 50 and 120 miles around the site were used to define two independent demand variables. In addition, two variables were defined to reflect the change in the regional demand for labor between the year construction began on the project and the year in which the survey was conducted.

These four variables were as follows:

- concurrent labor demand within a 50-mile radius of the site (DDR50);
- concurrent labor demand within a 120-mile radius of the site (DDR120);
- change in concurrent labor demand within a 50-mile radius of the site (CHDDR50); and
- change in concurrent labor demand within a 120-mile radius of the site (CHDDR120).

These data on concurrent labor demand were not available for the nonconstruction workforce. As a result, two alternative variables were developed and used in estimating the nonconstruction equation. These variables include:

- the number of other nuclear power plants already built in the region (ONB); and
- the number of other nuclear power plants currently under construction in the region (ONC).

³We were restricted to only using data on power plant construction because data on other construction activities in the area were not available.

4. Local Availability of Labor

The lack of data regarding the size of the available labor supply and unemployment rates of construction workers in the regions in question led us to define several proxy variables to capture the variation in the local availability of labor. The craft specific supply of labor was particularly difficult to measure. However, during the profile analysis, we observed a relationship between craft-specific migrant proportions at a site and the distance between the site and the nearest hiring hall of the union local with jurisdiction over the project. Because workers must report to union hiring halls for job referral, it can be argued that union hiring halls are likely to be located near construction employment opportunities and also that workers are more likely to live near their hiring halls. Accordingly, the supply of labor is likely to decline with increasing distance from the hiring halls. Based on this notion, we developed a proxy variable for the supply of labor. Specifically, the variable was defined as follows:

- o distance from the site to the hiring hall of the union local with jurisdiction over the project (DLOCAL).

Potentially, regional population size could also be used as a proxy for the supply of construction workers at a site. However, in our model population could also reflect regional attractiveness because population is generally associated with the type and amounts of services available in an area. In addition, population might reflect potential employment opportunities other than the nuclear power plant project. Thus, although the population variables may reflect both labor availability and the attractiveness of the region, the population variables are presented here as part of the regional characteristics of an area.

Lastly, local unemployment rates provide an indication of labor availability. In a study of this nature, one would ideally like to obtain craft-specific local unemployment rates. However, local unemployment rates (i.e., unemployment rates at the county level) were available only for the entire workforce. Nevertheless, we were able to predict county-level construction unemployment rates using predicting equations based on state data. Accordingly, four unemployment variables were developed and considered in this analysis:

- o regional overall unemployment rate (RUN);
- local overall unemployment rate (LUN);

- e regional construction unemployment rate (RCUN); and
- local construction **employment** rate (LCUN).

Again, not all of the above variables were included in estimating the nonconstruction equation. Distance from the union hiring hall and construction unemployment rates, for example, were not considered to be appropriate for the nonconstruction subgroup. Therefore, only the regional overall unemployment rate (RUN) and the local overall unemployment (LUN) rate were used as measures of local labor availability in estimating the nonconstruction equation.

5. Regional Characteristics

Several variables were defined to capture the characteristics of the region surrounding the site. These variables were defined in an effort to determine the relative attractiveness of the area to immigrating workers. Population, average community size and housing availability variables were included among these regional characteristic variables. The precise measures used, however, were often dictated by the availability of data, which at the county and community level was severely limited in years other than census years. The following regional characteristic variables were considered in estimating both the construction and nonconstruction equations:

- e Regional population (RPOP);
- Growth in regional population (RPOPGR);
- Average size of communities within 10 miles of the site (COMSZ10);
- Average size of communities within 25 miles of the site (COMSZ25);
- Housing vacancy rate (VACRT);
- Percent owner-occupied housing (PCTOWN);
- Number of housing units per capita (PCHSG);
- Number of mobile homes (PCMH); and
- Regional per capita income (RPCI).

6. Control Variables

In addition to the above variables, we identified a number of other variables which could also serve to explain the variation in migrant proportions across sites, and among various worker groups. These included:

- A dummy variable to identify workers from scarce crafts (SCAR);
- A dummy variable to identify workers from common crafts (COM);
- A dummy variable to identify the type of reactor (TYPE); and
- The size of units (in megawatts) under construction at the site (MWATT).

A similar set of control variables was used in estimating the nonconstruction equation. However, instead of using the SCAR and COM dummy variables, a management-clerical dummy variable was used. The variable was defined as follows:

- A dummy variable to identify management workers (MGCL).

Final Specification

The selection of the final specification was made based on empirical examination of the estimated equations under alternative specifications, i.e., inclusion and exclusion of different sets of variables. The decisions regarding inclusion and exclusion of variables, as well as the retention of variables in the equation, was based upon several considerations.

All variables which were defined to reflect the same explanatory factor were examined for colinearity. Variables which had simple correlation coefficients of .7 or more or which were alternative measures of the same characteristic, were not included in the equation simultaneously. In such cases, selection of the variable for inclusion in the final specification was made based upon a comparison of the performance of the variables in various regression equations (i.e., the variable which improved the R^2 the most or had the most significant coefficient was selected).

Variables which were defined to reflect different explanatory factors were also tested for colinearity. Between colinear variables (variables with simple correlation coefficients of .7 or more) the variable which we selected for inclusion in the final specification was the variable which, in our judgment, had a stronger theoretical basis for inclusion in the equation. In cases in which we had no a priori theoretical basis for making this determination, we selected the variable which had higher explanatory power (i.e., yielded a higher increase in R^2).

Finally, highly insignificant variables were examined to determine whether or not they were irrelevant to our specification. A variable was

considered to be irrelevant if (a) its 't' value was less than 1, (b) the magnitude of its standardized beta coefficient was relatively small, and (c) inclusion or exclusion of the variables from the estimated equation did not significantly alter the magnitude or significance of other coefficient estimates. All such variables were excluded from the final specification. The only exceptions to this occurred in the case of interaction terms. In general, interaction terms were avoided. They were included only if very strong prior belief or theoretical justification existed for considering interactions. In such cases, interaction terms were retained in the final equation irrespective of their significance or contribution to the equation.

RESULTS

The results of the final specification of the construction and non-construction worker equations are presented in Tables C-1 and C-2. Both equations performed remarkably well, explaining 71 and 87 percent of the variation in migrant proportions among the construction and nonconstruction groups. Variable coefficient estimates were generally found to be statistically significant and were of the expected sign. The estimated coefficients were also found to be robust. The sign and significance of key variables were not sensitive to the inclusion and exclusion of other variables in the equation. The results of the construction and nonconstruction worker equations are discussed in greater detail below.

Construction Worker Equation

As can be seen in Table C-1, a total of 18 variables were included in the final specification of the construction worker equation. Of these 18 variables, 16 were statistically significant at or above the 90 percent confidence level, and together the 18 variables explained about 71 percent of the variation in migrant proportions. Variables representing each of the explanatory factors were included in the final specification. Those variables which were defined to capture regional characteristics and labor requirements were found to be the most important in explaining the differences in craft-specific migrant proportions across surveys. With the exception of the duration of employment variables, all variables were of the expected sign. The results of the regression with

TABLE C-1

Migrant Proportion Regression Results
ConstructionDependent variable $\ln \frac{MPOP}{1-MPOP}$

Mean -1.43

Variable	Coefficient	t	
<u>Income Potential</u>			
Ln WAGE	1.58	1.83*	
Ln OTIME	3.41	3.92***	
<u>Labor Requirements</u>			
Ln CONT	1.19	4.48***	
Ln DEMP	-3.10	3.41***	
Ln (DEMP * SCAR)	.31	.36	
Ln (DEMP * COM)	1.87	2.32**	
Ln (GREMP * D1) ^a	.48	5.58***	
Ln (GREMP * D2) ^b	-.52	2.81***	
<u>Competing Demand for Labor</u>			
Ln DDR50	.48	4.62***	
<u>Local Availability of Labor</u>			
Ln DLOCAL	.21	1.79*	
<u>Regional Characteristics</u>			
Ln RPOP	1.71	3.59***	
RPOPGR	-1.11	4.56***	
Ln COMSZ25	-3.11	5.54***	
Ln COMSZ10	1.49	5.31***	
Ln VACRT	.16	5.67***	
<u>Control Variables</u>			
COM	-6.26	2.31**	
SCAR	1.10	.38	
Ln MWATTS	1.45	2.61***	
Constant	39.66	6.20***	
R ²	.71	R ²	.67
d.f.	115		

*** = p<.01; ** = p<.05; * = p<.10

^awhere: GREMP < 1, D1 = 1
otherwise, D1 = 0^bwhere: GREMP > 1, D2 = 1
otherwise, D2 = 0

TABLE C-2

Migrant Proportion Regression Results
Nonconstruction

Dependent variable $\ln \frac{\text{MPROP}}{1-\text{MPROP}}$ Mean = .26

Variable	Coefficient	t
<u>Competing Demand for Labor</u>		
Ln ONC	-.40	2.02**
<u>Local Availability of Labor</u>		
Ln RUN	-.61	2.05**
<u>Regional Characteristics</u>		
Ln RPOP	-.47	2.56**
<u>Control Variables</u>		
MGCL	1.70	13.59***
Ln MWATT	1.05	4.12***
Constant	-1.70	.69
R^2	.86	$\bar{R}^2$.84
d.f.	36	

*** = $p < .01$; ** = $p < .05$

respect to each of the explanatory factors identified in equation (2) are briefly discussed below.

1. Income Potential

For construction workers, the income potential associated with employment at the construction site is determined not only by their wage rate, but also by factors such as overtime rate, fringe benefits received, and the availability of travel allowances. In addition, because the nature of construction employment (i.e., the irregularity of employment), a number of other factors can also influence income potential for construction workers. These include factors such as the expected continuity and duration of employment. These variables, however, reflect differences in labor requirements associated with project construction and are included as part of our discussion of labor requirement variables.

Among the four variables defined to capture the variation in income potential across sites and survey, wage rate (WAGE) and overtime rate (OTIME) were found to be important in explaining migrant proportions. Both had the expected positive sign and were significant with the overtime rate variable showing a higher explanatory power than the wage rate variable. This supports the belief that overtime is a key component of high income among construction workers, and as a result serves as an important factor in attracting labor from other activities and areas. Travel allowances and fringe benefits were not found to influence migrant proportions in any significant way.

2. Labor Requirements

With respect to labor requirements, three factors were identified as important in estimating migrant proportion differentials across crafts and sites. These three factors include the expected growth of employment opportunities at the time of the survey (GREMP), the expected continuity of employment (CONT), and the expected duration of employment at the site (DEMP).

With respect to the expected growth of employment opportunities at the time of the survey, two variables were defined to capture whether employment opportunities at the construction site for a particular craft

group were at a prepeak stage (demand for labor was expected to increase) or at a postpeak stage (demand for labor was expected to decrease). The expected growth of employment opportunities at the time of the survey (GREMP) was defined as the ratio of the number of workers in a particular craft at the time of the survey to the highest employment expected during the remaining construction period. The value of this variable rises from a small fraction to 1 during the period in which employment is growing, and becomes greater than 1 during the subsequent periods when the employment at a site is declining. Since one would expect migrant proportions to rise during the period of increasing employment and decline during the period of decreasing employment, we did not enter the GREMP variable directly. Instead, two variables based on GREMP were defined. First, we defined GREMP*D1 (where $D1 = 1$ if $GREMP < 1$, otherwise $D1 = 0$) to capture the influence of increasing utilization of labor on migrant proportion. Similarly, we defined GREMP*D2 (where $D2 = 1$ if $GREMP > 1$, otherwise $D2 = 0$) to capture the influence of decreasing utilization of labor on migrant proportions. The coefficient estimates of both variables were significant and had the expected sign. These results indicate that the greater the expected increase in utilization of labor for a particular craft, the higher the migrant proportion and, similarly, the greater the expected decrease in utilization of labor for a particular craft, the lower the migrant proportion. This notion was confirmed by the highly significant and positive sign of the coefficient estimate of the continuity variable. In other words, crafts with greater continuity of employment were associated with higher migrant proportions. However, a similar association between projected duration of employment (duration of employment also serving to increase potential income associated with the move) and migrant proportions was not found to exist.

In fact, the duration variable (DEMP) coefficient estimate not only was of opposite sign, but was also significant. This would suggest that there are factors, other than income potential, which are related to the duration variable and are not separately considered in the estimated equation. These factors influence migrant proportions in the opposite direction. And, the influence of these factors is larger than the expected effect of the income potential associated with the duration variable.

One such factor might be the relationship between duration of employment for particular crafts and the relative availability of these workers in the area in which the site is located. Indeed, those crafts with the shortest expected duration are least likely to have adequate numbers of workers available in the region surrounding the site. Jobs of a limited duration, in general, tend to require more specialized skills and therefore workers from these crafts are scarce in relatively rural areas--the typical location of most nuclear power plants. The crafts which have the longest duration at nuclear power plant sites, on the other hand, are the unskilled crafts such as laborers. Typically, these have the lowest migrant proportions since they are more readily available locally.

Thus, we attempted to estimate the effect of the duration variable on migrant proportions separately for the scarce, common, and abundant craft groups. This was done by interacting dummy variables for the scarce and common craft groups with DEMP. (DEMP*SCAR) and (DEMP*COM) were introduced into the equation in addition to DEMP to capture the relationship between migrant proportions and DEMP separately for workers grouped into three scarcity groups⁴. In spite of this, we were unable to obtain the expected association for any of the craft groups. Since the coefficient estimate of DEMP*SCAR was small and extremely insignificant, it implied that there was no significant difference in the association between DEMP and migrant proportions for workers from the scarce and abundant (laborers and teamsters) craft groups. However, the coefficient estimate of DEMP*COM was significant. This implied that the association in question was different for workers from common craft groups. One should note that although the coefficient estimate of DEMP*COM was positive, it was smaller than the coefficient estimate of DEMP. Since the effect of increasing DEMP on the migrant proportions for workers from common crafts is obtained by summing the two coefficients, the effect was shown to be negative.

⁴The COM and SCAR variables are dummy variables defined to assume a value of 1 for common crafts and scarce crafts, respectively; and zero otherwise.

3. Competing Demand for Labor

The competing demand for workers from various crafts at other power plant construction projects in the region (DDRG50) was found to be related to migrant proportions. The competing demand estimate was found to be highly significant and positive. The competing demand variable which was based upon a 50-mile radius surrounding the construction entered the equation; however, the similar variable based upon 120-mile radius did not prove to be useful in explaining the differences in migrant proportions across crafts. This evidence suggests that power plant construction projects within commuting distance of the nuclear power plant draw workers from the same labor pool. However, in the case of more distant power plant construction projects, the impact of this factor on migrant proportion is insignificant. Change in competing demand for labor between the year construction began on the project and the year in which the survey was conducted did not enter the final equation.

4. Local Availability of Labor

The lack of data regarding the size of the available labor supply and unemployment rates of construction workers in the regions in question led us to define several proxy variables to capture the variation in the local availability of labor. However, several of these variables, such as regional population and average community size, could serve as proxies for both regional attractiveness and the local availability of labor. The supply of labor implications of these variables are included in our discussion of the regional characteristic variables.

During our profile analysis, we had observed a relationship between craft-specific migrant proportions at a site and the distance between the site and the hiring hall of the union local with jurisdiction over the project. Because workers must report to union hiring halls for job referral, it can be argued that union hiring halls are likely to be located near construction employment opportunities and also that workers are more likely to live near their hiring halls. Thus, for the purpose of this analysis we used distance from the site to the hiring hall of the union local with jurisdiction over the project (DLOCAL) as a proxy for the local availability of labor. As expected, the coefficient estimate

was found to be positive and significant. Since the further a construction site is located from the union hiring hall of a particular craft the lower the local availability of labor, one would expect to observe higher migrant proportion among the craft groups which have hiring halls at greater distance from the construction site.

5. Regional Characteristics

Regional characteristics were introduced as measures of the attractiveness of the region. However, as mentioned above, some of these variables could also be considered to be proxies of the local availability of labor. Since opposite signs are implied by these two factors and there is no a priori reason to argue which effect would be dominant, the sign of these variables could be either positive or negative. If the effect due to labor supply was larger than the effect due to regional attractiveness, then one would expect to observe a negative association between these variables and migrant proportions.

Among the 3 regional characteristic variables which could serve as proxy variables for both regional attractiveness and the local availability of labor--regional population, and average community sizes within 10 and 25 miles of the site--only the average community size within 25 miles of the site (COMSZ25) was found to be negatively associated with migrant proportion. A similar negative association was not found in the case of average community size within 10 miles of the site (COMSZ10). The opposite signs of these coefficients could be interpreted as suggesting that average community size very near the site (within 10 miles) serves more as a proxy for attractiveness because the largest of these communities are invariably too small to provide a significant pool of construction workers. Such is, of course, not the case when one considers communities located within 25 miles of the site. The attractiveness effect is clearly dominant in the case of regional population (RPOP).

The coefficient estimates of the two remaining regional variables (housing vacancy rate and population growth) were also found to be highly significant. Housing vacancy rate (VACRT) was found to be the most important variable in explaining the migrant proportions across sites. Higher vacancy rates were associated with higher migrant proportions.

Population growth (RPOPGR) was found to be negatively associated with migrant proportions. This result appears to suggest that population growth may be regarded by movers as a negative quality of a region. This is not unreasonable, since rapid population growth can be associated with shortage of housing and various services, which may be important elements in the decision process of immigrating workers.

6. Control Variables

Three variables in this category were included in the final equation. Two were dummy variables to capture the remaining mean differences among workers from the three scarcity groups. Only the dummy variable for workers from common craft (COM) was found to be statistically significant. This suggests that holding other variables constant, on average, workers from the common craft group have lower migrant proportions than workers from the other craft groups. The final control variable which we included was a variable which reflects the size (in megawatts) of the units under construction (MWATIS). The positive and highly significant coefficient estimate indicates that larger plants, on average, have higher migrant proportions associated with construction than one might have expected.

Nonconstruction Worker Equation

In the case of the nonconstruction worker equation the final specification was much simpler. As can be seen in Table C-2, only 5 variables were included in the final specification. A single dummy variable which was defined to capture the average differences between management and clerical workers was found to explain almost 75 percent of the variation in the dependent variable. However, four other variables--regional population, regional unemployment rate, number of other nuclear power plants under construction in the region, and plant size--also entered the final equation. These variables helped to explain only an additional 12 percent of the variation in migrant proportions among nonconstruction workers. All four variables were significant at or above the 95 percent confidence level.

The specific variables which were included in the nonconstruction worker equation differed to a large extent from those which were included

in the construction worker equation. The single most important variable in the nonconstruction worker equation was the management-clerical dummy (MGCL). This implies that the variation in migrant proportions among nonconstruction workers is mostly due to differences in migrant proportions of the management and clerical groups. The management workers had very high migrant proportions and the clerical workers very low migrant proportions.

The coefficient estimates of the overall unemployment rate in the region (RUN) and the regional population (RPOP) were both found to be negative and highly significant. The unemployment rate variable can be interpreted to mean that if there is a higher availability of labor in the area, one would expect to observe lower migrant proportions. The regional population variable, on the other hand, could reflect the general attractiveness of the area to immigrating workers or could reflect the size of the pool of local labor. The observed negative coefficient estimate suggests that with increasing regional population, the effect of the associated larger number of locally available workers is greater than the effect of the associated increased attractiveness of the area.

The number of other nuclear power plants currently under construction in the region (ONC) was entered into the equation as an indication of the competing demand for labor. However, the estimated coefficient of the variable had an unexpected negative sign. It is possible that the negative coefficient of this variable is a reflection of the stage of project completion of the other power plants. In general these plants were farther along than our study sites. Thus, it is possible that workers were transferred from these plants to the sites included in our study. However, owing to the proximity of the sites, many workers did not have to move because they lived within commuting distance of both construction sites.

Finally, the size of the units under construction (MWATIS) entered the equation and had an expected positive sign. Thus, as was observed in the construction worker equation, larger plants also have greater migrant proportions among their nonconstruction workers. This relationship was found to be very significant.

Unfortunately, detailed labor requirement data were not available for the nonconstruction workforce. Indeed, the only variable which was

available for the nonconstruction group was the number of workers on site at the time of the survey. This variable, however, did not enter the final nonconstruction worker equation.

DEFINITION OF VARIABLES - MIGRANT PROPORTIONS

I. Income Potential

- A. Wage rate (WAGE)--the straight-time hourly wage rate (first shift) for a journeyman as specified in the collective bargaining agreement of the union local with jurisdiction over the project.
- B. Overtime rate (OTIME)--the daily overtime rate (i .e., double-time was defined as "2.0").
- C. Fringe benefits (FRINGE)--the total dollar value of all fringe benefits paid per hour worked.
- D. Travel allowance (TALLOW)--a dummy variable indicating whether or not a particular craft had a travel allowance provision specified in its collective bargaining agreement.

II. Labor Requirements

- A. Expected continuity of employment (CONT)--the number of quarters in which projected average daily employment for a particular craft is greater than or equal to the average daily employment of the previous quarter.
- B. Expected duration of employment (DEMP)--the number of quarters in which projected average daily employment for a particular craft is greater than or equal to 25 percent of the highest projected average daily employment for any quarter.
- C. Expected growth of employment opportunities at the time of the survey (GREMP)--the ratio of the number of workers of a particular craft on site at the time of the survey to the projected average daily employment of the four highest consecutive quarters over the remaining construction period.
- D. Total projected employment (TEMP)--the total number of man-hours projected for a craft over the entire construction period.
- E. Number of workers on site at the time of the survey (NCRAFT)--the number of workers of a particular craft who completed the construction worker survey.
- F. Overall stage of project completion (PEAK)--a dummy variable indicating whether or not total employment at the site had reached the peak stage (had been relatively constant over a period of time).

- G. Expected peak employment (NPEAK)--the projected average daily employment for a particular craft for the highest projected quarter.
- H. Expected duration of peak (DPEAK)--the number of quarters in which projected average daily employment for a particular craft is greater than or equal to 75 percent of the highest projected average daily employment for any quarter.

III. Competing Demand for Labor

- A. Concurrent labor demand within a 50-mile radius of the site (DDR50)--the average annual labor requirements for a particular craft (in thousands of man-hours) at all other power plant construction projects within 50 miles of the site over the period of construction (from the year construction began through the year of the survey).
- B. Concurrent labor demand within a 120-mile radius of the site (DDR120)--the average annual labor requirements for a particular craft (in thousands of man-hours) at all other power plant construction projects within 120 miles of the site over the period of construction (from the year construction began through the year of the survey).
- C. Change in concurrent labor demand within a 50-mile radius of the site (CHDDR50)--the change in labor requirements for a particular craft (in thousands of man-hours) at all other power plant construction projects within 50 miles of the site over the period of construction (the difference between requirements in the year construction began and the year of the survey).
- D. Change in concurrent labor demand within a 120-mile radius of the site (CHDDR120)--the change in labor requirements for a particular craft (in thousands of man-hours) at all other power plant construction projects within 120 miles of the site over the period of construction (the difference between requirements in the year construction (the difference between requirements in the year construction began and the year of the survey)).
- E. Other nuclear power plants already built in the region (ONB)--the total number of other nuclear power plant units already completed within 50 miles of the construction site.

- F. Other nuclear power plants currently under construction in the region (ONC)--the total number of other nuclear power plant units currently under construction within 50 miles of the construction site.

IV. Local Availability of Labor

- A. Distance to the union hiring hall (DLOCAL)--the distance (in miles) from the construction site to the hiring hall of the union local with jurisdiction over the project.
- B. Regional overall unemployment rate (RUN)--the average unemployment rate (weighted by civilian labor force) of all counties in the region within 50 miles of the construction site over the period of construction (from the year construction began through the year of the survey).
- C. Local overall unemployment rate (LUN)--the average unemployment rate (weighted by civilian labor force) of all counties in the local area (the county in which the site is located plus any adjoining county within 15 highway miles of the site) over the period of construction (from the year construction began through the year of the survey).
- D. Regional construction unemployment rate (RCUN)--a construction unemployment rate for the region calculated from the overall unemployment rate as defined above (RUN) based upon a relationship derived from data at the state level.
- E. Local construction unemployment rate (LCUN)--a construction unemployment rate for the local area calculated from the overall unemployment rate as defined above (LUN) based upon a relationship derived from data at the state level.

V. Regional Characteristics

- A. Regional population (RPOP)--total population of all counties within 50 miles of the construction site for the year in which construction began.
- B. Growth in regional population (RPOPGR)--change in the population of the region (all counties within 50 miles of the site) between 1970 and 1975 expressed as a proportion of the 1970 population.

- C. Average size of communities within 10 miles of the site (COMSZ10)--the total population of communities within 10 miles of the construction site divided by the number of communities.
- D. Average size of communities within 25 miles of the site (COMSZ25)--the total population of communities within 25 miles of the construction site divided by the number of communities.
- E. Housing vacancy rate (VACRT)--the number of vacant units divided by total housing units in 1970 for counties in the local area multiplied by 100.
- F. Percent owner-occupied housing (PCTOWN)--owner-occupied housing units as a proportion of all occupied housing units in 1970 for counties in the local area.
- G. Number of housing units per capita (PCHSG)--total housing units in the local area in 1970 divided by the 1970 population.
- H. Number of mobile homes per capita (PCMH)--total number of mobile homes in the local area in 1970 divided by the 1970 population.
- I. Regional per capita income (RPCI)--weighted average of per capita income (weighted by population) of counties within 50 miles of the site for the year construction began.

VI. Control Variables

- A. Scarce (SCAR)--a dummy variable indicating whether or not a craft belonged to the scarce craft group.
- B. Common (COM)--a dummy variable indicating whether or not a craft belonged to the common craft group.
- C. Type of reactor (TYPE)--a dummy variable indicating whether a particular reactor is a pressurized water reactor or a boiling water reactor.
- D. Size of units (MWATT)--the total number of megawatts in all units under construction at the site.
- E. Management (MGCL)--a dummy variable indicating whether or not nonconstruction workers belonged to the management group.

APPENDIX D

RESIDENTIAL LOCATION MULTIVARIATE ANALYSIS

APPENDIX D

RESIDENTIAL LOCATION MULTIVARIATE ANALYSIS

This Appendix presents a more detailed discussion of the residential location analysis which was conducted in the multivariate analysis portion of this study. The purpose of the analysis was to explain the observed variation in residential location patterns of immigrating workers across the sites included in our sample. The results of this analysis served as the basis for specifying procedures for forecasting residential location patterns at future nuclear power plant construction sites. The discussion is divided into three sections. The first section discusses the factors involved in residential location decisions, noting several factors which may be special considerations of construction workers. The second section describes the residential location model and the third section describes the analysis results.

FACTORS INVOLVED IN RESIDENTIAL LOCATION DECISIONS

Numerous factors underlie most residential location decisions. Decisions are governed by the needs of an individual or family--the preference for a particular size and housing type--and the availability and cost of housing, as well as the general attractiveness of the area and the proximity of the location to work, schools, shopping, and various other services. One important factor, and a factor which is likely to be of particular importance in the context of this study, is the residential location with respect to the place of employment. An important factor in many individuals' residential location decisions is the desire to minimize the time and cost associated with the journey-to-work. Since in this study we focus upon a specific work place, it is logical to examine residential location patterns of immigrating workers in terms of the distance from the construction site.

The special nature of the construction industry has some implications regarding movers' residential location decisions. Many of the workers move to the area to work on the project with the intention of leaving the area upon completion of the project. Especially among the more specialized construction crafts, many movers are employed for jobs of rather limited duration. Some of these movers do not relocate their families. In fact, many live in the area only during the workweek and return to

their permanent residence each weekend. It is quite likely that minimizing the time and cost associated with getting to work is the major factor in the residential location decisions of these temporary and transient movers.

While workers may seek to live as close to the site as possible, other factors enter the residential location decision. The importance of other factors, however, may differ for different groups of workers. For example, a worker who relocates his family, and in particular a permanent mover who expects to remain in the area upon completion of the project, is much more likely to consider other factors such as the quality of schools, shopping and services, and perhaps the location of other employment opportunities in the area. Larger population centers in general reflect the availability of goods and services, including the availability of housing and, as such, may serve to attract immigrating workers. Furthermore, because different groups of workers differ in the nature of employment opportunities (i.e., the expected duration and continuity of employment), in their intention to remain in the area, and in the likelihood of relocating their families, one might also expect to observe differences in residential location decisions. Indeed, differences in the residential location patterns of operating and construction workforces have been observed at energy development projects in the Great Plains.¹

In summary, the residential location decisions of movers at a large construction project are likely to depend upon the housing availability, regional attractiveness and workforce composition at the site. We analyze the effects of these factors on the residential location decisions of movers among the surveys included in our sample within the framework of a modified gravity model. We use the specification of a gravity model only as a starting point in the development of our residential location model. The way in which we modify the gravity model in an attempt to overcome some of the weaknesses of gravity models is described in the following section.

¹J. S. Wieland, F. L. Leistritz, and S. H. Murdock, "Characteristics and Residential Patterns of Energy-Related Work Forces in the Northern Great Plains," Western Journal of Agricultural Economics, (July, 1979), pp. 57-68.

RESIDENTIAL LOCATION MODEL

The gravity model captures the trade-offs between the size of communities and the distance of communities from their place of work which workers face in making residential location decisions. The basic form of the gravity model is as follows:

$$(1) \quad I_{ij} = \frac{A \cdot \text{POP}_j^\alpha}{\text{DIST}_{ij}^\beta}$$

where:

- I_{ij} = the number of workers residing in community j , who worked at site i ;
- POP_j = population of community j ;
- DIST_{ij} = distance between community j and site i ;
- α = the exponent of population;
- β = the exponent of distance; and
- A = the constant of proportionality.

In the gravity model, population acts as a proxy for both the attractiveness of a community and the ability of the community to absorb immigrants. Distance, on the other hand, acts as a proxy for the costs (both in terms of time and money) associated with locating away from one's place of work. The values of the estimated exponents are determined by the choices made by individuals which, in turn, depend upon their personal tastes and preferences, the nature of their employment, and the geography of the region (i.e., the number, sizes, and types of communities available in the area surrounding the sites). Accordingly, the exponents are likely to vary across sites and across different groups of workers at the same site (i.e., construction/non-construction workers, skilled/unskilled workers). It is for this reason that exponent estimates obtained from the estimation of a gravity model at one site do not usually perform very well in predicting residential location patterns at another site.

To overcome these limitations we modify the gravity model to allow both population and distance exponents to vary across worker groups and across sites as follows:

$$(2) \quad \text{PMOVE}_{ijk} = \frac{A \cdot \text{POP}_{ij}^{\alpha_{ik}}(X_i, Y_i)}{\text{DIST}_{ij}^{\beta_{ik}}(X_i, Y_i)}$$

where:

- PMOVE_{ijk} = the proportion of movers from worker group k who work at site i and reside in community j ;
- POP_{ij} = population of community j at site i ;
- DIST_{ij} = distance between community j and site i ;
- α_{ik} = the exponent of population at site i for worker group k ;
- β = the exponent of distance at site i for worker group k ;
- A = the constant of proportionality;
- X_i = project characteristics at site i ; and
- Y_i = regional characteristics of site i .

A linear estimating equation of the following form can be specified by applying a logarithmic transformation to the above equation and assuming that the population (α) and distance (β) exponents are a linear function of vectors of the regional (Y) and project (X) characteristics.

$$(3) \quad \text{LnPMOVE}_{ijk} = \text{Ln}A + (a_1 + a_2X_i + a_3Y_i)\text{LnPOP}_{ij} - (b_1 + b_2X_i + b_3Y_i)\text{LnDIST}_{ij} + \epsilon_{ij}$$

This equation allows each site to have its own population and distance exponents. The population and distance exponents in this equation are given by $(a_1 + a_2X_{ik} + a_3Y_i)$ and $(b_1 + b_2X_{ik} + b_3Y_i)$ respectively. Thus, the magnitude of the population and distance exponents is not fixed, but rather depends upon the regional and project characteristics of the site in question. Equation (3) can be rewritten as follows:

$$(4) \quad \text{LnPMOVE}_{ij} = \text{Ln}A + a_1\text{LnPOP}_{ij} + a_2X_i\text{LnPOP}_{ij} + a_3Y_i\text{LnPOP}_{ij} - b_1\text{LnDIST}_{ij} - b_2X_i\text{LnDIST}_{ij} - b_3Y_i\text{LnDIST}_{ij} + \epsilon_{ij}$$

where:

$\ln A$, a_1 , a_2 , a_3 , b_1 , b_2 , and b_3 are the coefficients to be estimated.

We used this very general form of the gravity model to begin our empirical work. However, during our preliminary analysis we found two reasons to modify our specification. First, the population interaction terms and the distance interaction terms contained in equation (4) were found to be highly correlated. This was due to the fact that larger communities are generally located farther from construction sites and the same set of regional and project characteristics were defined to explain the variations in the population and distance exponents. Since there was no strong theoretical basis to justify using different sets of X and Y variables to explain the variations in the population and distance exponents, in our analysis we revised our specification and assumed the population exponent to be fixed for all sites and allowed only the distance exponent to vary across sites.

Second, we estimated the basic gravity model as specified in equation (1) separately for 3 major worker groups--nonconstruction workers, scarce construction crafts and other construction crafts--for each survey to confirm whether or not the distance exponents of the three groups were different. This hypothesis was tested using the standard Chow test. We found that in only a few cases were the distance exponents found to be significantly different among worker groups at a site. Accordingly, we revised our specification to allow the gravity model exponents to vary across sites but not across worker groups. The specification which was finally estimated was as follows:

$$(5) \quad \ln \text{PMOVE}_{ij} = \ln A + a \ln \text{POP}_{ij} + b_1 \ln \text{DIST}_{ij} - b_2 X_i \ln \text{DIST}_{ij} \\ - b_3 Y_i \ln \text{DIST}_{ij} + \epsilon_{ij}$$

Definition of Variables

Several variables were defined to capture the influence of the various regional and project characteristics upon the distance exponent. In general 4 groups of variables were examined. These include regional attractiveness, housing availability, workforce composition and other project characteristics and control variables. The specific variables

which were examined in each group are discussed briefly below. The precise variable definitions are included at the end of this appendix.

1. Regional Attractiveness

Several variables were defined in an attempt to reflect the attractiveness of the area to immigrating workers. These variables include:

- distance from the site to the nearest SMSA (DSMSA);
- employment in the retail trade industry in the local area (RETEMP);
- employment in the service industries in the local areas (SVCEMP);
- population growth in the local area (LPOPGR); and
- per capita income in the local area (LPCI).

Distance from the nearest SMSA and per capita income were included to capture the general attractiveness of the area immediately surrounding the site. Similarly, employment in the service industries and employment in the retail trade industries in the local area were included as surrogates for amenities and services in nearby communities. Finally, population change in the local area was included because rapid population growth in the area immediately surrounding the site could be associated with shortages of housing and various services, factors which could influence movers' residential location patterns.

The distribution of population and communities around the site are important determinants of the residential location patterns of immigrating workers. To summarize the population and community information around a site, we defined population sizes, numbers of communities and average community sizes for various distance intervals from the site. Specifically, the following variables were considered:

- the population of communities within 10, 15, 20, and 25 miles of the site (POP10, POP15, POP20, POP25);
- the number of communities within 10, 15, 20, and 25 miles of the site (NCMTY10, NCMTY15, NCMTY20, NCMTY25); and
- the average size of communities with 10, 15, 20 and 25 miles of the site (COMSZ10, COMSZ15, COMSZ20, COMSZ25).

These distance intervals were chosen arbitrarily. Several intervals were selected to explore the distribution of population and communities surrounding the site in an effort to identify the set of variables which best explain the residential location differences across various worker groups.

2. Housing Availability

The availability of housing in the local area could be a key determinant of the residential location patterns of immigrating workers. Accordingly, we considered the following housing availability variables in this analysis:

- housing vacancy rate (VACRT);
- number of mobile homes per capita (PCMH);
- percent owner-occupied housing (PCTOWN); and
- number of housing units per capita (PCHSG).

3. Workforce composition and Other Project Characteristics

We examined several variables in an attempt to capture the residential location preferences of different groups of workers. This was done by introducing variables defined to reflect differences in workforce composition at the time of the survey. These variables included:

- total number of movers (NMOVE);
- proportion of movers from scarce crafts (PS);
- e proportion of movers from other construction crafts (PO);
- a dummy variable indicating whether or not total employment at the site had reached the peak stage (PEAK); and
- e a dummy variable indicating whether or not total employment at the site had reached the postpeak stage (PPEAK).

4. Control Variables

In addition to the above variables we identified one control variable which could also serve to explain the variation in residential location patterns. The following variable was considered:

- a dummy variable to identify whether the site is located in the North or in the South (REGION).

Final Specification

The selection of the specific variables included in the final specification was made based on empirical examination of the estimated equations under alternative specifications, i.e., inclusion and exclusion of different sets of variables. The decisions regarding inclusion and exclusion of variables, as well as the retention of variables in the equation, was based upon three considerations.

First, all variables which were defined to capture the same factor were examined for colinearity. Variables which had simple correlation

coefficients of .7 or more or which were alternative measures of the same characteristic, were not included in the equation simultaneously. In such cases, selection of the variable for inclusion in the final specification was made based upon a comparison of the performance of the variables in various regression equations (i.e., the variable which improved the R^2 the most or had the most significant coefficient was selected).

Second, variables which were defined to reflect different factors were also tested for colinearity. Between colinear variables (variables with simple correlation coefficients of .7 or more) the variable which we selected for inclusion in the final specification was the variable which, in our judgment, had a stronger theoretical basis for inclusion in the equation. In cases in which we had no a priori theoretical basis for making this determination, we selected the variable which had higher explanatory power (i.e., yielded a higher increase in R^2).

Finally, highly significant variables were examined to determine whether or not they were irrelevant to our specification. A variable was considered to be irrelevant if (a) if it had a high 't' value, (b) the magnitude of its standardized beta coefficient was relatively small, and (c) inclusion or exclusion of the variables from the estimated equation did not significantly alter the magnitude or significance of other coefficient estimates. All such variables were excluded from the final specification.

RESULTS

The results of the final specification of the residential location equation are presented in Table D-1. In general, the equation performed quite well, explaining over 60 percent of the variation in residential location patterns among the 24 surveys included in the equation. For the most part, variable coefficient estimates were found to be statistically significant and were of the expected sign. The estimated coefficients were also found to be robust. The sign and significance of key variables were not sensitive to the inclusion and exclusion of other variables in the equation. These results suggest that the explanatory variables included in the estimated equation do, indeed, capture many of the factors underlying the variation in residential location patterns.

As expected, our multivariate analysis did indicate that the proportion of movers locating in a particular community is positively related

TABLE D-1

Residential Location Regression Results

Dependent variable Ln PMOVE		Mean -4.999	
Variable	Coefftcient	t	
<u>Ln POP</u>	.385	21.103***	
<u>Ln DIST</u>	-.917	5.455***	
<u>Distance Interaction Terms</u>			
RETEMP * Ln DIST	-.094	2.300**	
DSMISA * Ln DIST	.083	.907	
VACRT * Ln DIST	-.053	2.153**	
PCMH * Ln DIST	-6.399	2.068**	
NMOVE * Ln DIST	-.019	2.787***	
PS * Ln DIST	-.433	2.523***	
PO * Ln DIST	-.312	2.017**	
REGION	.133	2.354**	
Constant	-2.897	15.275***	
R ²	.605	R ²	.600
d.f.	832		

*** = p<.01; ** = p<.05

to **community** size (POP), and negatively related to the distance from the construction site (DIST). Both variables were significant at the 99 percent confidence level. Eight other variables were included in the final specification in an attempt to capture differences in the distance exponent as a function of regional attractiveness, housing availability, workforce composition and other project characteristics, and control variables. Of these 8 variables, **7** were significant at or above the 95 percent confidence level.

In the gravity model estimation the distance coefficient has a negative sign (indicating an inverse relationship between distance and the dependent variable). A higher distance exponent can be interpreted to mean that movers will tend to locate nearer the construction site and a smaller distance exponent means that movers will tend to locate farther away. In the modified gravity model as specified in the previous section, the estimate of the distance exponent is given by the linear combination of the distance term and the various interaction terms. Thus, the coefficient estimates of the interaction terms affect the magnitude of the distance exponent--increasing **it if** the coefficient is negative and decreasing **it if** the coefficient is positive. The coefficient estimates of the various interaction terms can, therefore, be examined to determine the influence of these variables upon the distance coefficient. The results of the regression equation with respect to each of the explanatory factors identified above are briefly discussed below.

Regional Attractiveness

Several variables were defined to capture the general attractiveness of the area immediately surrounding the site. Two of these variables--distance from the nearest SMSA (DSMSA) and employment in retail trade industries in the local area (RETEMP)--entered the final equation. The negative coefficient estimate of the retail trade variable implies that sites with higher retail trade activity in the local area are more likely to have higher proportions of movers living close to the site than are sites with lower retail activity in the local area. Similarly, with respect to distance from the nearest SMSA, the positive coefficient estimate indicates that those sites at greater distances from the nearest SMSA have smaller distance exponents and therefore lower proportions of

movers living in communities near the construction site. Sites which are located nearer SMSA's, on the other hand, have correspondingly higher proportions of movers living in communities immediately surrounding the construction site. Thus, evidence suggests that workers prefer to live closer to SMSAs. These results are consistent with what one would expect to observe. The estimated coefficient of the retail trade variable was significant at the 95 percent confidence level. In the case of the distance from the nearest SMSA, however, the coefficient was not found to be significantly different from zero at the 90 percent confidence level.

In addition, we examined the importance of several variables which were intended to capture distribution of population and communities surrounding the construction site. To summarize the population and community characteristics of a site, we defined population sizes, numbers of communities and average community sizes for various distance intervals from the site. These variables, however, did not enter our final equation.

Housing Availability

The availability of housing in the local area is clearly a factor in the residential location decisions of immigrating workers. Accordingly, we considered the following housing availability variables in this analysis: housing vacancy rate (VACRT); percent owner-occupied housing (PCTOWN); number of housing units per capita (PCHSG); and number of mobile homes per capita (PCHH). Two of these variables, namely vacancy rate and number of mobile homes per capita, entered the final equation. As expected, both coefficient estimates were negative and highly significant. Thus, these results indicate that higher vacancy rates and mobile homes per capita in the local area are associated with higher proportions of movers living in nearby communities. The importance of mobile homes reflects the temporary nature of employment in the construction industry.²

²In our profile analysis we observed that rather large proportions of movers live in mobile homes, especially in Southern sites. Twenty of the 24 surveys included in this analysis were conducted at Southern sites.

Workforce Composition and Other Project Characteristics

In addition, several variables were examined in an attempt to capture the residential location preferences of different groups of movers. This was done by introducing variables defined to reflect differences in workforce composition at the site at the time of the survey. Three such variables--total number of movers at the site (NMOVE), proportions of movers from the scarce crafts (PS), and proportion of movers from the common and abundant crafts (PO)--were included in the final equation. Our results indicate that the total number of movers is an important variable. As the total number of movers increases, higher proportions of movers tend to locate nearer the construction site. Similarly, if the proportion of construction movers is higher (compared with nonconstruction movers), then one observes higher proportions of movers living nearer the construction site. Among construction movers, if the proportion of movers from scarce crafts is higher, then higher proportions of movers are likely to live closer to the site. This is consistent with the differences in the potential duration of employment at the site among the various worker groups. Clearly, movers whose employment potential at the site is of a shorter duration are willing to live closer to the site than other workers, despite the relatively less attractive communities and available housing closer to the site. The 2 variables which were introduced to capture overall stage of project completion (PEAK and PPEAK) did not enter our final equation.

Control Variables

Finally, we examined the effect of several control variables upon the distance exponent. Only one--REGION--was shown to be significant. The region variable is a dummy variable which was defined to have a value of one if the site was located in the South and zero otherwise. Thus, the results suggest that holding other variables constant, on average, movers in the South tend to live farther from the construction site than movers in the North.

Differences in Distance Exponents

Perhaps a better understanding of these results can be achieved by examining the distance exponents implied by the estimated equation. The coefficient estimates were used to estimate distance exponents for each

of the 24 surveys included in our analysis. These estimates are presented in Table D-2. The distance exponents thus computed ranged from approximately 1.2 to 1.6. It is important to note that distance exponents vary not only across sites, but also at the same site at different stages of project completion. The reason for this is that although most variables included in the equation are site-specific variables, the workforce composition variables are survey-specific. Thus, as workforce composition changes, so also does the distance exponent. Comparing estimated exponents for those sites at which multiple surveys were conducted, it can be seen that distance exponents, in general, increase as construction on the project progresses toward peak employment. This is because in relation to the nonconstruction workforce the size of the construction workforce increases during peak employment. This relationship is perhaps best illustrated by a comparison of the three surveys conducted at Site 10. One will note that the estimated distance exponent of the second survey (10.2) which was conducted during peak employment was higher than the estimated distance exponent of the first survey (10.1) which was conducted during the prepeak stage. Furthermore, one will observe that as employment decreased during the postpeak stage (10.3), the estimated distance exponent also decreased. This implies that as employment decreases at a site, the movers living nearer the site are the first to leave. This is consistent with the evidence found during our profile analysis that temporary movers are more likely to locate closer to the site than are permanent movers.

TABLE D-2

**Distance Coefficients as Estimated Based
Upon the Residential Location Equation**

<u>Survey Identification Number</u>	<u>Estimated Distance Coefficient</u>
1.0	-1.49
2.0	-1.48
3.0	-1.54
4.0	-1.54
8.0	-1.61
9.1	-1.32
9.2	-1.39
9.3	-1.47
9.4	-1.59
10.1	-1.28
10.2	-1.44
10.3	-1.27
11.1	-1.32
11.2	-1.46
11.3	-1.43
11.4	-1.52
12.1	-1.18
12.2	-1.33
12.3	-1.44
12.4	-1.55
13.1	-1.27
13.2	-1.34
13.3	-1.48
13.4	-1.52

REFERENCES

- Wieland, J. S.; Leistritz, F.L.; and Murdock, S. H. "Characteristics and Residential Patterns of Energy-Related Work Forces in the Northern Great Plains." Western Journal of Agricultural Economics, (July, 1979), pp. 57-68.

DEFINITION OF VARIABLES - RESIDENTIAL LOCATION

I. Regional Attractiveness

- A. Distance from the nearest SMSA (DSMSA)--distance of the site (in hundreds of miles) from the central city of the nearest SMSA.
- B. Employment in the retail trade industry in the local area (RETEMP)--per capita employment in retail trade in the local area for the year construction began (i.e., total number of workers employed in retail trade divided by the population of the local area) multiplied by the population of all communities within 15 miles of the site (in thousands).
- C. Employment in the service industry in the local area (SVCEMP)--per capita employment in services in the local area for the year construction began (i.e., total number of workers employment in the service industry divided by the population of the local area) multiplied by the population of all communities within 15 miles of the site (in thousands).
- D. Growth in local population (LPOPGR)--change in the population of the local area between 1970 and 1975 expressed as a proportion of the 1970 population.
- E. Local per capita income (LPCI)--weighted average (weighted by population) of counties in the local area (the county in which the site is located plus any adjoining county within 15 highway miles of the site) for the year construction began.
- F. Population of nearby communities (POP10, POP15, POP20, POP25)--the total population of communities (in thousands) within 10, 15, 20, and 25 miles of the site.
- G. Number of nearby communities (NCMTY10, NCMTY15, NCMTY20, NCMTY25)--the number of communities within 10, 15, 20, and 25 miles of the site.
- H. Average size of nearby communities (COMSZ10, COMSZ15, COMSZ20, COMSZ25)--the total population of communities divided by the number of communities within 10, 15, 20, and 25 miles of the site.

II. Housing Availability

- A. Housing vacancy rate (VACRT)--the number of vacant units divided by total housing units in 1970 for counties in the local area multiplied by 100.

- B. Number of mobile homes per capita (PCMH)--total number of mobile homes in the local area in 1970 divided by the 1970 population.
- C. Percent owner-occupied housing (PCTOWN)--owner-occupied housing units as a proportion of all occupied housing units in 1970 for counties in the local area.
- D. Number of housing units per capita (PCHSG)--total housing units in the local area in 1970 divided by the 1970 population.

III. Workforce Composition and Other Project Characteristics

- A. Total number of movers (NMOVE)--the total number of movers for all worker groups at the site at the time of the survey (in hundreds of movers).
- B. Proportion of movers from scarce crafts (PSI)--the total number of movers from scarce crafts divided by the total number of movers at the site at the time of the survey.
- C. Proportion of movers from other construction crafts (PO)--the total number of movers from the common and abundant crafts divided by the total number of movers at the site at the time of the survey.
- D. Peak employment (PEAK)--a dummy variable indicating whether or not total employment at the site had reached the peak stage (had been relatively constant over a period of time).
- E. Postpeak employment (PPEAK)--a dummy variable indicating whether or not total employment at the site had reached the postpeak stage (had begun to decline).

IV. Control Variables

- A. Region (REGION)--a dummy variable indicating whether or not the site is located in the North or in the South.

APPENDIX E

VALIDITY OF THE FORECASTING PROCEDURES

APPENDIX E

VALIDITY OF THE FORECASTING PROCEDURES

In this appendix we provide some evidence regarding the validity of the forecasting procedures described in Chapter IV of this report. This discussion is divided into 3 sections. The expected accuracy of the proposed procedures for predicting migrant proportions and residential location patterns of immigrating workers is discussed in the first two sections. The final section includes a brief discussion of the validity of the procedures for predicting other variables important in socio-economic impact assessment, *i.e.*, the number of movers who will relocate their families, the intention of movers to remain in the area beyond completion of the project, the type of housing selected and marital status of immigrating workers.

MIGRANT PROPORTIONS

Results of the estimated model were used to establish the validity of the proposed procedures to estimate the overall migrant proportions at nuclear power plant construction sites. The validity of the model, and therefore of the forecasting procedures developed from them, is attested by (1) the large amount of variation explained by the model, (2) robustness of the estimated coefficients and residuals, (3) consistency of the explained variation, and (4) the difference in the predicted and actual overall migrant proportions in the 21 surveys included in the sample.

Explained Variation

Over seventy percent of the variation in migrant proportions among the surveys included in the study is explained by the estimated construction worker equation. This **implies** a correlation between actual and predicted values of 85 percent. Since we are interested in overall migrant proportions rather than in the migrant proportions of workers in individual crafts, the estimated equation can be expected to perform even better. If the unexplained variation is due to random errors associated with the variables included in the equation, then the correlation between

overall (aggregated across 7 crafts) actual and predicted migrant proportions would be much higher. And, indeed, it was 95 percent in the case of construction worker equation. In the case of the nonconstruction worker equation nearly 85 percent of the variation in migrant proportions is explained by the estimated equation. This suggests that the estimated equations can be expected to predict extremely well at sites with characteristics which are within the range of characteristics of the sites included in our sample.

Robustness of the Coefficients

The coefficient estimates of key variables in our equations were found to be stable with respect to (1) inclusion and exclusion of control variables in the equation (discussed in Appendix C of this report), and (2) estimating the equation using subsets of the data, i.e., estimating the equation excluding all observations (a total of 7 craft groups) from one site at a time. We estimated five such equations separately for construction and nonconstruction workers. Tables E-1 and E-2 present a comparison of these regression results. The equations in which single sites were excluded exhibited remarkable consistency when compared with the equation which included all sites (as well as when compared with the equations which excluded other single sites). In the case of both the construction and nonconstruction worker equations, the magnitude and significance of the coefficient estimates do not show much variation across equations. The sign of each coefficient estimate is the same in all equations. Finally, it should be noted that there is no significant loss in the amount of variation explained when the equation is estimated using subsets of the data.

As a more formal test, we used the "F" values associated with the Chow test to determine whether or not the excluded observations may be considered to come from the same population.¹ With the exception of

¹Note that this is a special case of the Chow test in which the number of observations associated with the excluded site is less than the number of parameters. Under these conditions a variant of the test can be performed as suggested by Johnson. See J. Johnson, Econometric Methods, (New York: McGraw Hill Book Company, Inc., 1972), p. 207.

TABLE E-1

Construction Worker Migrant Proportion Regression
Results for Subsets of Sites
(standard error in parentheses)

	All Sites	Excluding Survey 1.0	Excluding Survey 2.0	Excluding Survey 3.0	Excluding Survey 4.0	Excluding Survey 8.0
	$R^2 = .71$	$R^2 = .71$	$R^2 = .72$	$R^2 = .73$	$R^2 = .73$	$R^2 = .67$
	$\bar{R}^2 = .67$	$\bar{R}^2 = .66$	$\bar{R}^2 = .68$	$\bar{R}^2 = .69$	$\bar{R}^2 = .68$	$\bar{R}^2 = .62$
<u>Income 'potential</u>						
Wage	1.58* (.86)	1.70* (1.02)	1.70* (.90)	.56 (.91)	1.82* (.98)	1.46 (.93)
Overtime	3.41* (.87)	3.09* (1.03)	3.87* (.97)	2.08* (.94)	4.32* (.97)	3.34* (.94)
<u>Labor Requirements</u>						
Continuity of Employment	1.19* (.27)	1.09* (.40)	1.14* (.27)	1.36* (.27)	1.00* (.30)	1.06* (.38)
Duration of Employment I	-3.10* (.91)	-3.23* (.94)	-2.88* (.97)	-2.34* (.84)	-3.18* (.93)	-3.38* (.96)
Duration of Employment II	-.31 (.87)	-.42 (.92)	-.54 (.93)	-.59 (.85)	-.62 (.89)	-.27 (.91)
Duration of Employment III	1.87* (.80)	1.92* (.82)	1.64* (.87)	.87 (.76)	1.90* (.83)	1.93* (.82)
Prepeak Stage	.48* (.09)	.47* (.09)	.49* (.09)	.47* (.08)	.47* (.09)	.48* (.09)
Postpeak Stage	-.52* (.18)	-.55* (.19)	-.54* (.18)	-.49* (.17)	-.45* (.18)	-.51* (.20)
<u>Competing Demand for Labor</u>						
Employment at other plants in the region	.48* (.10)	.50* (.11)	.52* (.11)	.50* (.10)	.46* (.11)	.50* (.11)
<u>Local Availability of Labor</u>						
Distance from the union local	.21* (.12)	.17* (.14)	.21* (.12)	.25* (.12)	.19 (.14)	.23* (.13)
<u>Regional Characteristics</u>						
Regional Population	1.71 *	1.81* (.53)	1.87* (.57)	1.81* (.52)	1.79* (.48)	1.90* (.54)
Regional Population Growth	-1.11 * (.24)	-1.15* (.25)	-1.19* (.25)	-1.11* (.23)	-1.05* (.26)	-1.15* (.27)
Average Community Size - 25 miles	-3.11* (.56)	-3.33* (.68)	-3.30* (.58)	-3.16 (.56)	-3.08* (.56)	-3.36* (.75)
Average Community Size - 10 miles	1.49* (.28)	1.59* (.33)	1.59* (.30)	1.52* (.28)	1.47* (.28)	1.60* (.36)
Housing vacancy rate	.16* (2.75)	.17* (3.69)	.17* (2.90)	.15* (2.54)	.15* (2.77)	.17* (4.06)
<u>Control Variables</u>						
Common	-6.26* (2.71)	-6.50* (2.76)	-5.49* (2.92)	-2.28 (2.62)	-6.49* (2.79)	-6.43 (2.77)
Scarce	1.10 (2.91)	1.36 (3.06)	1.86 (3.12)	2.71 (2.87)	2.01 (2.96)	1.01 (3.01)
Size of Units	1.45* (.56)	1.86* (1.01)	1.52* (.56)	1.49* (.64)	1.15* (.59)	.93 (1.07)
Constant	39.66 (6.40)	41.98* (6.94)	40.88* (6.49)	36.61* (5.97)	40.20* (6.77)	49.64* (19.13)
Chow test	--	.76	1.58	4.69	1.56	.43

* Coefficient is significant at the 90% confidence level.

TABLE E-2
Nonconstruction Worker Migrant Proportion Regression
Results for Subsets of Sites
(standard error in parentheses)

	All Sites	Excluding Survey 1.0	Excluding Survey 2.0	Excluding Survey 3.0	Excluding Survey 4.0	Excluding Survey 8.0
	$R^2 = .86$	$R^2 = .88$	$R^2 = .86$	$R^2 = .85$	$R^2 = .85$	$R^2 = .88$
	$\bar{R}^2 = .84$	$\bar{R}^2 = .86$	$\bar{R}^2 = .84$	$\bar{R}^2 = .83$	$\bar{R}^2 = .83$	$\bar{R}^2 = .86$
<u>Competing Demand For Labor</u>						
Other nuclear power plants under construction	-.40* (.20)	-.46* (.17)	-.05 (.24)	-.36* (.20)	-.37* (.21)	-.52* (.19)
<u>Local Availability of Labor</u>						
Regional Unemployment Rate	-.61* (.30)	-.90* (.28)	-.44 (.30)	-.60* (.30)	-.58* (.31)	-.97* (.30)
<u>Regional Characteristics</u>						
Regional Population	-.47* (.18)	-.58* (.17)	-.11 (.24)	-.51* (.19)	-.51* (.21)	-.70* (.18)
<u>Control Variables</u>						
Occupation	1.70* (.13)	1.64* (.11)	1.71* (.12)	1.69* (.13)	1.70* (.13)	1.70* (.12)
Size of Units	1.05* (.26)	1.51* (.28)	.81* (.27)	1.06* (.26)	1.07* (.27)	.18 (.38)
Constant	-1.70 (2.46)	-3.12 (2.22)	-5.07* (2.81)	-1.20 (2.55)	-1.32 (2.68)	8.85* (4.20)
Chow test	--	6.43	2.52	.51	.09	4.44

* Coefficient is significant at the 90% confidence level.

only one construction worker equation and 2 nonconstruction worker equations, we were unable to reject the null hypothesis that the observations come from the same population at the 95 percent level of confidence. These results, therefore, seem to suggest that the underlying parameters of the estimated model are the same for the excluded sites as for the other sites. However, one has greater confidence in the case of the construction worker equation than in the case of the nonconstruction worker equation.

The results, thus, clearly demonstrate the robustness of the estimated model. They show that there is a systematic variation in migrant proportions which is successfully captured by our specification. **If it** were not, then the likelihood of observing this level of stability in the estimated equations and their coefficients is extremely small.

The equation which was estimated excluding a particular site was then used to predict migrant proportions at that site. Table E-3 presents a comparison of these predicted values with both actual migrant proportions and the migrant proportions which were predicted using the equation estimated including all sites.

In comparing actual migrant proportions with migrant proportions predicted using the estimated equation in which the particular site was excluded, some rather pronounced differences were observed. ~~We~~ observed a very pronounced difference between actual and predicted values for both construction and nonconstruction groups at only one site. However, in the case of the nonconstruction group, at two additional sites the difference between actual and predicted values was greater than 20 percentage points. Although the evidence is by no means overwhelming, **it** does indicate a need to be cautious regarding the use of the forecasting procedures developed in this study at future construction sites. **It** is important to recognize that the forecasting procedures are not likely to perform too well at sites with important characteristics outside the range of the characteristics of the sites included in our sample.

In all cases the difference between actual and predicted migrant proportions was much smaller when all sites were included in the estimated equation compared with when the site in question was excluded. This, however, is not surprising considering the small number of sites in

TABLE E-3

A Comparison of Predicted and Actual Migrant Proportions
Using Various Equation Estimates

	<u>Migrant Proportion (Construction)</u>	<u>Migrant Proportion (Nonconstruction)</u>
<u>Survey 1.0</u>		
Actual	13.1	43.6
Predicted (all sites)	12.3	28.9
Predicted (Survey 1.0 excluded)	7.5	20.3
<u>Survey 2.0</u>		
Actual	13.8	29.1
Predicted (all sites)	17.0	36.7
Predicted (Survey 2.0 excluded)	17.3	51.7
<u>Survey 3.0</u>		
Actual	20.3	49.5
Predicted (all sites)	15.3	43.9
Predicted (Survey 3.0 excluded)	11.7	43.0
<u>Survey 4.0</u>		
Actual	23.5	40.0
Predicted (all sites)	22.6	37.9
Predicted (Survey 4.0 excluded)	25.5	36.9
<u>Survey 8.0</u>		
Actual	50.5	33.7
Predicted (all sites)	48.2	41.8
Predicted (Survey 8.0 excluded)	67.6	67.0

our sample. In fact, 4 of the 9 sites which were included in the analysis are TVA sites and these sites have many similar characteristics. Thus, the exclusion of a single site from our sample is likely to reduce the range of variation in key variables which are important for purposes of generalization. These relatively small deviations between the actual and predicted values would suggest that the generalizability of the model could have been considerably improved by a larger sample of sites in our data set.

Consistency of Explained Variance and Residuals

Further evidence which lends confidence in the equation can be found in the comparison of the mean square values of the explained variation and the residuals for the various equations estimated--including all sites and those in which observations from single sites were excluded. These mean square values are shown in Table E-4. Once again, the critical finding is that mean square values show very little variation. The mean square regression ranged from 4.28 to 5.29 in the case of the construction worker equation and from 6.36 to 6.99 in the case of the non-construction worker equation. This is a reflection of the existence of systematic variation in migrant proportions of crafts within and across sites, and the ability of our model to consistently capture approximately 70 percent of that variation. This robustness and consistency which is observed in these results greatly increases the confidence which one might have in applying these forecasting procedures at future construction sites.

Predicted and Actual Overall Migrant Proportion

The final test of the proposed forecasting procedure lies in how well it would predict the overall (for all workers) migrant proportion at a site. Accordingly, we compared the predicted values generated by the proposed forecasting procedures with the actual values in the case of all the 21 surveys which were included in our estimation. The overall migrant proportions were estimated by predicting the numbers of migrants in each of the 7 construction crafts using the coefficient estimates of construction equation. (It should be noted that in the estimation of this equation, all 7 crafts were not included in the case of all the

TABLE E-4

Summary of Explained and Unexplained Variation in
the Estimated Equations - Migrant Proportions

	<u>Mean square regression</u>	<u>Mean square residual</u>
<u>Construction worker equation</u>		
All sites	5.29	.335
Excluding Survey 1.0	4.94	.340
Excluding Survey 2.0	5.11	.324
Excluding Survey 3.0	4.51	.274
Excluding Survey 4.0	5.17	.324
Excluding Survey 8.0	4.28	.347
<u>Nonconstruction worker equation</u>		
All sites	6.99	.164
Excluding Survey 1.0	6.39	.126
Excluding Survey 2.0	6.36	.151
Excluding Survey 3.0	6.66	.169
Excluding Survey 4.0	6.68	.173
Excluding Survey 8.0	6.72	.138

surveys because in some crafts there were too few workers on the site at the time of the survey.) In addition, the number of migrants was estimated for the other construction craft group. The numbers of migrants among nonconstruction (clerical and management) workers were estimated using the coefficient estimates of the nonconstruction equation. The weighted average of these numbers was used to obtain the overall migrant proportion predicted by the proposed forecasting procedure.

A comparison of predicted and the actual overall migrant proportions is presented in Table E-5. As can be seen in the table, the difference between the actual and predicted values, in most cases, was small. The mean absolute deviation was only 2.9 percentage points and the root-mean-square deviation was only 3.7 percentage points. Thus, not only is the expected value of the error small, but the likelihood of a forecasting error of 7.5 percentage points is low. In fact, in over 80 percent of the cases, the error did not exceed ± 5 percentage points. This comparison illustrates the kind of precision one can expect from using the proposed procedures to predict migrant proportion at sites similar to those included in our study. The relatively low variation in the difference between actual and predicted overall migrant proportions is an added testimony of the precision and appropriateness of the models used in developing the forecasting procedure.

RESIDENTIAL LOCATION

A similar set of tests was used to examine the validity of the proposed procedures for estimating residential location patterns of immigrating workers at nuclear power plant construction sites. Almost sixty percent of the variation in residential location patterns of movers is explained by the estimated equation. As in the case of migrant proportions, several other factors also serve to lend support to the validity of the model. These include: (1) robustness of the estimated coefficients and residuals, (2) consistency of the explained variation, and (3) the differences in the predicted and actual proportions of movers living at various distance intervals from the construction site.

TABLE E-5

Overall Migrant Proportions
A Comparison of Actual and Predicted Values

<u>Survey Identification Number</u>	<u>Predicted</u>	<u>Actual</u>	<u>Deviation</u>
1.0	16.9	21.0	-4.1
2.0	19.2	15.3	3.9
3.0	17.2	24.7	-7.5
4.0	22.9	25.2	-2.3
8.0	46.1	46.9	-.8
9.1	25.1	29.7	-4.6
9.2	31.3	32.8	-1.5
9.3	31.8	32.7	-.9
9.4	36.5	30.1	6.4
11.1	19.6	18.0	1.6
11.2	18.8	23.4	-4.6
11.3	31.7	32.8	-1.1
11.4	34.6	40.3	-5.7
12.1	18.8	18.9	-.1
12.2	23.5	23.7	-.2
12.3	28.7	29.6	-.9
12.4	35.9	31.7	4.2
13.1	21.6	15.8	5.8
13.2	21.6	18.9	2.7
13.3	23.8	25.9	-2.1
13.4	25.5	25.5	0.0

Mean absolute deviation 2.9
Root-mean-square deviation 3.7

Robustness of the Coefficients

The coefficient estimates of key variables were found to be stable with respect to the inclusion and exclusion of various control variables (see Appendix D) and also when all communities associated with single sites were excluded from the regression. As was the case in our migrant proportion analysis, five such equations were estimated. A comparison of the coefficient estimates and the standard errors of equations including all sites and in which single sites were excluded is presented in Table E-6. As can be seen from the table, the sign significance and magnitude of the coefficient estimates, as well as the corresponding R^2 , remain quite stable despite the exclusion of different sets of observations from the analysis. Once again, we used the "F" values associated with the Chow test to determine whether or not the excluded observations may be considered to come from the same population. In all cases we were unable to reject the null hypothesis that the observations come from the same population at the 95 percent confidence level.

Consistency of Explained Variance and Residuals

A comparison of the mean square values of the explained variation and the residuals for the various equations estimated--including all sites and those in which all observations from single sites were excluded--was also made. These results are presented in Table E-7. As was true in the case of the migrant proportion equations, one observes that the mean square values exhibit little variation when single sites are excluded. The mean square of the regression ranged from 102.29 to 109.95 and the mean square of the residual ranged from .860 to .880. Thus, the robustness, consistency and stability of the regression equation serve to increase our confidence in the application of these forecasting procedures at future construction sites.

Predicted and Actual Residential Location Patterns

Finally, the estimated residential location equation was examined with respect to how well it would predict residential location patterns among the surveys included in our study. However, owing to the number of communities surrounding each construction site, a comparison of actual and predicted values is more difficult than was true for migrant

TABLE E-6

Residential Location Regression Results for Subsets of Data
(standard error in parentheses)

	All Sites	Excluding Survey 1.0	Excluding Survey 2.0	Excluding Survey 3.0	Excluding Survey 4.0	Excluding Survey 8.0
	$R^2 = .605$	$R^2 = .609$	$R^2 = .608$	$R^2 = .603$	$R^2 = .604$	$R^2 = .600$
	$\bar{R}^2 = .600$	$\bar{R}^2 = .604$	$\bar{R}^2 = .603$	$\bar{R}^2 = .598$	$\bar{R}^2 = .599$	$\bar{R}^2 = .595$
<u>Population</u>	.385* (.018)	.383* (.018)	.390* (.019)	.383* (.019)	.385* (.019)	.380* (.019)
<u>Distance</u>	-.917* (.168)	-.925* (.170)	-.961* (.169)	-.935* (.176)	-.902* (.186)	-1.038* (.201)
<u>Distance Inter- action Terms</u>						
Local retail activity	-.094* (.041)	-.090* (.042)	-.107* (.047)	-.108* (.056)	-.094* (.042)	-.103* (.041)
Distance from SMSA	.083 (.091)	.072 (.093)	.053 (.103)	.041 (.146)	.083 (.100)	.141 (.101)
Housing vacancy rate	-.053* (.025)	-.052* (.025)	-.051* (.026)	-.045 (.035)	-.053* (.028)	-.022 (.035)
Per capita mobile homes	-6.399* (3.095)	-5.883* (3.335)	-6.106* (3.171)	-5.408 (4.124)	-6.368* (3.788)	-5.524* (3.161)
Total number of movers	-.019* (.007)	-.018* (.007)	-.018* (.007)	-.020* (.007)	-.019* (.007)	-.021* (.007)
Proportion scarce	-.433* (.171)	-.443* (.172)	-.445* (.172)	-.394* (.201)	-.432* (.185)	-.336* (.187)
Proportion other construction	-.312* (.155)	-.344* (.172)	-.276* (.165)	-.276 (.184)	-.314* (.168)	-.328* (.155)
Region	.133* (.056)	.121* (.064)	.126* (.059)	.107 (.090)	.132* (.062)	.134* (.056)
Constant	-2.897* (.190)	-2.811* (.193)	-2.794* (.196)	-2.886* (.193)	-2.953* (.197)	-2.934* (.193)
Chow test	--	1.182	1.060	.860	.730	1.072

* Coefficient is significant at the 90% confidence level.

TABLE E-7

Summary of Explained and Unexplained Variation in
the Estimated Equation - Residential Location

	<u>Mean square regression</u>	<u>Mean square residual</u>
All sites	109.95	.864
Excluding Survey 1.0	108.31	.860
Excluding Survey 2.0	106.88	.862
Excluding Survey 3.0	106.50	.868
Excluding Survey 4.0	104.44	.880
Excluding Survey 8.0	102.29	.861

proportions. For this reason we examined the actual and predicted proportions of movers living in 5-mile intervals of the site. Table E-8 presents a comparison of actual and predicted values for each of the 24 surveys for which predictions were made.

The final two columns in Table E-8 contain the mean absolute deviation between actual and predicted values and the root-mean-square deviation for each of the distance bands. It is interesting to note that the highest average differences occurred in the 6-10 and 21-25 mile distance bands. In most other distance bands differences were relatively small. It is likely that the observed differences between actual and predicted values stem from specific attractive or unattractive features of particular communities surrounding a construction site. Limited resources did not allow us to explore more fully the characteristics underlying these differences. Such aspects of the problem would undoubtedly be subjects for future research efforts. Nevertheless, by utilizing a model which explicitly incorporates various regional and project characteristics (i.e., regional attractiveness, housing availability and workforce composition), one can expect the proposed forecasting procedures to improve the accuracy of residential location predictions compared with methods which have been previously used to allocate movers to various communities surrounding large construction projects.

PERSONAL AND HOUSEHOLD CHARACTERISTICS OF MOVERS

Because of the different way in which the procedures for forecasting the personal and household characteristics of movers were developed, our examination of the validity of the proposed forecasting procedures was limited to a comparison of actual and predicted values.

The proposed forecasting procedures were used to estimate the overall proportions of movers with family present among the 24 surveys for which information on the relocation of dependents was available. A comparison of actual and predicted values is presented in Table E-9. In general, the differences between actual and predicted values were not very large. The mean absolute deviation and the root-mean-square deviation were 5.4 and 7.5 percentage points, respectively. In 5 out of 24 cases, however, the difference between actual and predicted values exceeded 10 percentage

TABLE E-8

**Proportions of Movers Living at Various Distances from the Site
A Comparison of Actual and Predicted Values**

Distance Interval (miles)	Survey 1.0		Survey 2.0		Survey 3.0		Survey 4.0		Survey 8.0		Survey 9.1		Survey 9.2		Survey 9.3		Survey 9.4	
	Act	Proj	Act	Proj	Act	Proj	Act	Proj	Act	Proj	Act	Proj	Act	Proj	Act	Proj	Act	Proj
0-5	1	5	18	11	32	37	9	15	6	13	13	10	12	10	11	10	12	10
6-10	70	71	31	30	3	9	14	32	22	36	62	57	60	56	56	59	53	66
11-15	10	5	2	5	10	12	7	7	17	10	4	8	4	7	6	6	6	5
16-20	11	8	6	8	43	24	44	18	6	12	3	1	3	1	1	1	2	1
21-25	1	1	20	18	7	8	7	5	43	16	4	6	5	6	4	5	5	3
26-30	3	4	13	8	0	1	2	4	2	3	3	2	2	2	4	3	3	2
31-35	1	1	1	1	2	4	7	6	1	2	1	1	1	2	2	3	3	2
36-40	1	1	1	4	1	4	1	2	1	1	2	5	4	5	2	3	4	2
41-80	3	5	8	15	2	2	9	11	3	6	9	9	9	11	14	11	13	9

Distance Interval (miles)	Survey 10.1		Survey 10.2		Survey 10.3		Survey 11.1		Survey 11.2		Survey 11.3		Survey 11.4		Survey 12.1		Survey 12.2	
	Act	Proj	Act	Proj	Act	Proj	Act	Proj	Act	Proj	Act	Proj	Act	Proj	Act	Proj	Act	Proj
0-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6-10	61	57	60	60	42	38	73	66	65	66	66	64	56	67	38	40	36	44
11-15	0	0	0	0	0	0	0	0	2	4	2	2	1	4	20	10	20	7
16-20	12	13	17	8	18	12	21	22	21	16	20	19	33	16	18	23	12	16
21-25	1	1	1	1	1	1	1	5	3	3	3	4	3	3	1	5	4	6
26-30	7	11	8	7	10	10	1	3	1	3	1	3	1	4	6	4	10	8
31-35	3	5	2	3	4	6	1	0	1	2	1	2	1	2	10	8	6	4
36-40	3	3	1	2	2	3	1	3	1	2	2	2	2	2	3	3	2	3
41-80	13	10	11	20	23	30	1	1	6	4	6	4	3	4	4	9	10	12

Distance Interval (miles)	Survey 12.3		Survey 12.4		Survey 13.1		Survey 13.2		Survey 13.3		Survey 13.4		Mean Absolute Deviation	Root-Mean- Square Deviation
	Act	Proj	Act	Proj	Act	Proj	Act	Proj	Act	Proj	Act	Proj		
0-5	0	3	0	3	4	5	3	4	2	5	2	5	3.4	4.1
6-10	32	45	31	53	19	35	16	33	16	41	16	44	9.4	12.6
11-15	21	9	22	8	8	10	13	11	10	10	11	10	4.2	6.3
16-20	19	15	23	13	5	7	7	7	9	6	8	6	5.5	8.6
21-25	3	5	3	4	51	16	44	15	38	12	37	11	7.0	17.3
26-30	9	7	7	5	1	2	1	1	1	2	1	2	1.6	2.0
31-35	6	6	3	3	5	1	5	1	6	1	7	1	1.6	2.3
36-40	1	2	3	4	1	1	1	2	3	3	3	3	1.0	1.4
41-80	8	9	8	8	7	23	9	26	15	20	15	18	4.0	6.1

* Percents may not add to 100 due to rounding.

TABLE E-9

Proportion of Movers with Family Present
A Comparison of Actual and Predicted Values

<u>Survey Identification Number</u>	<u>Predicted</u>	<u>Actual</u>	<u>Deviation</u>
1.0	57.3	51.8	5.5
2.0	50.9	53.1	-2.2
3.0	49.5	52.0	-2.5
4.0	50.9	51.8	-.9
8.0	65.1	63.1	2.0
9.1	68.6	51.9	16.7
9.2	68.0	71.2	-3.2
9.3	66.9	71.5	-4.6
9.4	65.4	67.0	-1.6
10.1	67.9	80.5	-12.6
10.2	65.1	63.5	1.6
10.3	68.5	85.7	-17.2
11.1	69.4	73.0	-3.6
11.2	66.6	66.0	.6
11.3	67.5	73.6	-6.1
11.4	67.2	68.2	-1.0
12.1	71.0	73.4	-2.4
12.2	67.8	76.2	-8.4
12.3	66.7	68.7	-2.0
12.4	65.2	64.0	1.2
13.1	70.5	58.2	12.3
13.2	69.3	58.4	10.9
13.3	67.9	60.8	7.1
13.4	67.8	64.4	3.4

Mean absolute deviation 5.4
Root-mean-square deviation 7.5

points. This would suggest that there may be a need for a more elaborate analysis of relocation of dependents, as was conducted for migrant proportions and residential location. Such an analysis certainly would have produced superior prediction procedures. Nonetheless, these procedures do represent an improvement in forecasting procedures over merely using overall average values across all sites.

Similarly, with respect to intention to remain in the area, the forecasting procedures were used to predict the proportion of movers who are temporary for the 4 sites in our sample for which overall intention to remain in the area could be determined. A comparison of the actual and predicted values is presented in Table E-10. As can be seen in the table, the results were quite good, with a mean absolute deviation of only 1 percentage point and a root-mean-square deviation of only 1.6 percentage points. These results reflect only 4 sites and, therefore, cannot be assumed to be reliable.

A comparison of the actual and predicted proportions of movers living in each of 4 different types of housing among the 24 surveys in our data set is presented in Table E-11. In a few instances the differences between actual and predicted values was quite large, while in other instances the difference were relatively small. Mean absolute deviations for houses, mobile homes, apartments and other housing were 4.8, 6.5, 3.8, and 3.6 percentage points, respectively. The corresponding root-mean-square deviations were 6.9, 7.9, 5.5, and 4.4 percentage points. Further improvement in forecasting procedures can not be made without performing a multivariate analysis. This level of accuracy, however, may be sufficient for purposes of recognizing the kind of housing pressures that are likely to result around nuclear power plant construction sites.

Finally, the proposed forecasting procedures were used to estimate the proportion of movers who are married at each of the 7 sites in our data set for which information on marital status was available. A comparison of actual and predicted values is presented in Table E-12. In general, the estimated proportions and actual proportions were rather close. The mean absolute deviation was only 3.4 and the root-mean-square deviation was 4.1.

TABLE E-10
Percent Temporary
A Comparison of Actual and Predicted Values

<u>Site Identification Number</u>	<u>Predicted</u>	<u>Actual</u>	<u>Deviation</u>
1.0	59.	59.	0.
2.0	53.	55.	-2.
8.0	52.	50.	2.
9.4	52.	52.	0.
Mean absolute deviation	1.0		
Root-mean-square deviation	1.6		

TABLE E-11

Housing Choice of Movers by Type
A Comparison of Actual and Predicted Values

Survey Identification Number	House (%)			Mobile Home (%)			Apartment (%)			Other (%)		
	Predicted	Actual	Deviation	Predicted	Actual	Deviation	Predicted	Actual	Deviation	Predicted	Actual	Deviation
1.0	44.0	35.4	8.6	15.9	20.5	-4.6	29.4	33.3	-3.9	10.7	10.8	-.1
2.0	39.2	38.8	.4	20.1	19.9	.2	25.3	29.6	-4.3	15.4	11.7	3.7
3.0	38.2	38.5	-.3	21.0	23.4	-2.4	24.5	17.9	6.6	16.3	20.1	-3.8
4.0	37.2	41.6	-4.4	21.9	18.4	3.5	23.5	23.4	.1	17.4	16.6	.8
8.0	38.2	38.7	-.5	38.6	48.8	-10.2	14.8	8.3	6.5	8.3	4.2	4.1
9.1	44.1	29.7	14.4	32.6	48.7	-16.1	16.2	14.4	1.8	7.0	7.2	-.2
9.2	44.3	37.1	7.2	32.4	44.3	-11.9	16.3	13.8	2.5	7.0	4.8	2.2
9.3	40.8	37.6	3.2	36.0	41.1	-5.1	15.4	16.5	-1.1	7.8	4.9	2.9
9.4	38.5	38.1	.4	38.3	41.6	-3.3	14.9	16.0	-1.1	8.2	4.4	3.8
10.1	43.6	55.4	-11.8	33.1	27.7	5.4	16.1	10.1	6.0	7.1	6.8	.3
10.2	39.0	33.1	5.9	37.8	37.7	.1	15.0	14.5	.5	8.1	14.7	-6.6
10.3	45.3	64.4	-19.1	31.4	26.7	4.7	16.5	5.5	11.0	6.8	3.4	3.4
11.1	46.8	45.4	1.4	29.8	36.2	-6.4	16.9	15.6	1.3	6.4	2.8	3.6
11.2	40.6	32.9	7.7	36.2	42.8	-6.6	15.4	14.8	.6	7.8	9.5	-1.7
11.3	42.8	38.6	4.2	33.9	41.2	-7.3	15.9	15.6	.3	7.3	4.5	2.8
11.4	42.6	38.4	4.2	34.1	28.5	5.6	15.9	30.3	-14.4	7.6	2.8	4.8
12.1	50.1	44.3	5.8	26.4	40.5	-14.1	17.7	6.3	11.4	5.7	8.9	-3.2
12.2	43.8	45.8	-2.0	32.9	40.6	-7.7	16.1	8.9	7.2	7.1	4.7	2.4
12.3	41.4	41.9	-.5	35.4	35.9	-.5	19.7	16.5	3.2	7.6	5.6	2.0
12.4	38.4	43.6	-5.2	38.5	36.2	2.3	14.8	14.8	0	8.3	5.5	2.8
13.1	48.9	44.4	4.5	27.7	22.2	5.5	17.4	18.3	-.9	6.0	15.0	-9.0
13.2	45.8	45.8	0	30.8	22.6	8.2	16.6	18.1	-1.5	6.7	13.6	-6.9
13.3	43.3	43.7	-.4	33.5	22.3	11.2	16.0	19.4	-3.4	7.2	14.5	-7.3
13.4	43.3	47.4	-4.1	33.4	21.2	12.2	16.0	16.8	-.8	7.2	14.7	-7.5
Mean absolute deviation			4.8	6.5			3.8			3.6		
Root-mean-square deviation			6.9	7.9			5.5			4.4		

TABLE E-12
Percent Married
A Comparison of Actual and Predicted Values

<u>Survey Identification Number</u>	<u>Predicted</u>	<u>Actual</u>	<u>Deviation</u>
1.0	75.2	69.9	5.3
2.0	76.1	71.5	4.6
3.0	76.2	76.6	-.4
4.0	76.4	80.7	-4.3
8.0	84.7	83.8	.9
9.4	84.6	81.1	3.5
12.4	84.7	89.2	-4.5

Mean absolute deviation 2.9

Root-mean-square deviation 3.7

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