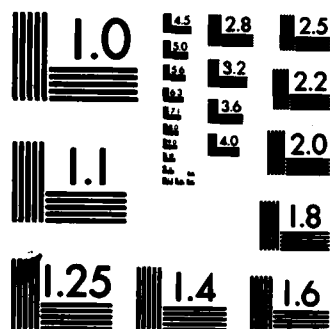


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US Army Corps
of Engineers
Engineer Institute for
Water Resources

16

Replacement Employment Impacts of Corps Construction Projects

Final Report

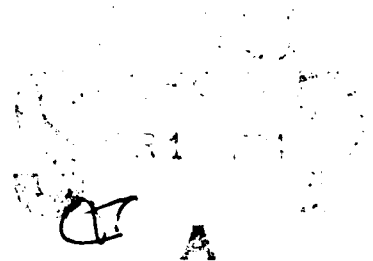
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January 1984

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Contract Report 84-C-1



Final Report has been approved
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**REPLACEMENT EMPLOYMENT IMPACTS
OF CORPS CONSTRUCTION PROJECTS**

**Final Report
Contract #DACW72-82-C-0005**

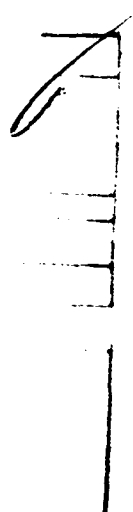
**Submitted to:
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September 1983



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ABSTRACT

The objective of this research was to develop a procedure for measuring the replacement employment impacts of Corps construction projects. Conceptually these effects refer to the employment opportunities associated with job vacancies created when employed workers leave jobs to take employment on Corps construction projects. Such vacancies may allow a chain reaction of employment upgrading as underemployed or otherwise unemployed workers move into vacated jobs. The report presents a methodology for measuring replacement employment effects which relies heavily on secondary data on interindustry labor mobility and interindustry earnings differentials coupled with data obtained from workforce surveys. The use of secondary data surmounts the time consuming and expensive task of backtracking through vacated jobs to identify replacement employment. Workforce surveys supply information about prior employment as well as about earnings which represent the computational base for recalculating the opportunity cost associated with filling vacated jobs. The approach was tried at two case studies - the Lakeview, Texas, project and the Lock and Dam 26 in St. Louis. The workforce surveys established that there was interindustry movement into construction occupations, and that vacancies were being created in other industrial sectors besides construction. The secondary national data yielded mobility and earnings differential matrices which appeared to offer reasonable models of the replacement process. Given the assumptions employed by the contractor, the replacement employment impacts of the case study projects were quite large amounting to approximately 104 percent of annual earnings of workers employed at the Texas site and 76 percent of the average annual earnings the the St. Louis site. Further research will need to be done in order to address certain weaknesses in the present research, however. These weaknesses pertain to two unfounded assumptions made by the contractor, and also in our current lack of understanding about the sources of variation in the key variables on which estimates of replacement employment impacts depend. The first unsupported assumption is that every job vacated will be filled.

The second assumption is that vacated jobs would be filled in two weeks time. Additional research should focus on obtaining better understanding of the dynamics of job replacement. In addition, the two case studies yielded quite different patterns of interindustry labor mobility. Additional research should analyze the sources of variability among projects and the importance of variables such as local labor market conditions, union status of project, etc, in accounting for such variation. While preliminary research begins to articulate a set of benefits which have not been counted or even acknowledged by the Corps. These benefits are important in a national economic accounting framework and further refinement of the methodology has the potential for creating the basis for their quantitative measurement and inclusion into formal benefit/cost analysis. Such effects are also important to localities interested in improving employment opportunities. This methodology offers a way to focus attention on this aspect of Corps projects.

TABLE OF CONTENTS

1.0	Introduction	1
2.0	Conceptual Framework and Approach	5
2.1	Direct Employment Impacts	5
2.2	Replacement Employment Impacts	7
2.3	Information Requirements to Estimate Direct and Replacement Employment Impacts	8
2.4	Approach	10
3.0	Case Study Surveys	11
3.1	Methodology	11
3.1.1	Survey Instrument	12
3.1.2	The Pre-test Survey	14
3.1.3	Survey Administration	14
3.1.4	Data Preparation and Processing	15
3.2	Lakeview Lake, Mountain Creek Texas, Fort Worth District United States Army Corps of Engineers	15
3.2.1	Detailed Project Description	15
3.2.2	Survey Approach—Lakeview Dam Project, Texas	17
3.2.3	Survey Findings—Lakeview Dam Project, Texas	17
3.3	The Lock and Dam (L & D) No. 26 — St. Louis District United States Army Corps of Engineers	22
3.3.1	Detailed Project Description	26
3.3.2	Survey Approach - L & D 26 Project, Illinois/Missouri	28
3.3.3	Survey Findings - L & D Project, Illinois/Missouri	28
4.0	Direct and Replacement Employment Impacts at Case Study Projects	39
4.1	Impact Estimation Procedure	39
4.1.1	Direct Employment Impact Estimation Procedure	39
4.1.2	Replacement Impact Estimation Procedure	40
4.2	Data Requirements	45
4.2.1	Estimation of the Mobility and Earnings Differential	45

TABLE OF CONTENTS (continued)

4.2.2	Replacement Lag	48
4.2.3	Survey Data	49
4.2.4	Other Required Data	51
4.3	Employment Impacts at Texas Case Study Site	53
4.3.1	Direct Impacts	53
4.3.2	Replacement Impacts	53
4.3.3	Total Employment Impacts	54
4.4	Employment Impacts at St. Louis Case Study Site	54
4.4.1	Replacement Impacts	55
4.4.2	Total Employment Impacts	55
5.0	Procedural Implications for Anticipatory Studies	57
5.1	Direct Impact Estimation	57
5.2	Replacement Impact Estimation	58
5.3	Questions for Future Research	60
REFERENCES		63

FOREWORD

One of the nationally significant effects of public works projects is the impact of construction and operation on unemployment. Utilization of otherwise unemployed persons to build or operate such projects results in a net gain in national and regional well-being. The long history of support for federal water resource evaluation procedures which attempt to capture such "area redevelopment" or "employment benefits" underscores the continuing importance which policy makers have placed on the contribution that water resource projects can make in combating unemployment.

The Institute for Water Resources has had a substantial program of research directed toward developing credible and empirically based procedures to better identify the employment effects of Corps construction projects. This research has resulted in the creation of a data base and set of analytic procedures for measuring direct employment benefits of Corps construction projects.

The research presented in this report continues IWR's interest and involvement in measuring the contribution of Corps construction projects to national and regional socioeconomic well-being. The research presented represents a first attempt to measure what are termed replacement employment effects of Corps construction projects. These effects may be created when already employed workers elect to obtain employment on construction projects. Vacancies created by workers may allow a "domino-effect" chain reaction of employment upgrading as employed workers move forward to take higher paying jobs. Differences in wages associated with such movements become measures of changes in productivity and measures of underemployment. At some point in this process an otherwise unemployed worker can enter the chain and a reduction in the unemployed labor pool results.

To date replacement employment effects have not been well documented, and theoretical and practical problems concerning the operationalization and measurement of these effects remain to be solved. It should again be emphasized that this research is a first attempt to measure these effects; conclusions drawn are based in part upon a number of assumptions which need more research.

Nevertheless, we feel that the findings merit publication as research in progress because they begin to articulate a set of benefits which could have importance in a national accounting framework as further research is performed. Replacement employment effects are also likely to be important to localities interested in improving employment opportunities. The research reported here offers a way to focus attention on this aspect of Corps projects.

JAMES R. HANCHEY
Director, IWR

1.0 Introduction

Appropriate analysis of "otherwise unemployed" resources in the construction and operation of public works projects continues to be a troublesome issue facing economists and project planners.¹ The basic principle involved is not the point of difficulty. Economists agree that in a competitive economy at full employment, the market price of a factor of production accurately represents the true cost to society of using that resource. If, however, the economy is operating at less than full employment, the true cost to society of employing previously underutilized resources is less than the market price of these resources. In the case of totally idle or unemployed resources, the cost is zero. Thus, theoretically, cost-benefit calculations should be adjusted to reflect the utilization of "otherwise unemployed" resources. The troublesome issue is how, in fact, to implement the necessary cost adjustment.

The same information is seen by local residents from a different, but equally significant, perspective. If a public works project is to generate employment in a region among persons who would otherwise be unemployed, its positive economic impacts are likely to be judged as being very beneficial by local residents. These positive impacts may take several forms. There may be direct employment of previously unemployed, direct employment of previously employed who are in turn replaced by unemployed workers, or fuller and more productive utilization of previously employed workers. Regardless of the form it takes, each of the above amount to fuller utilization of an area's human resource base with concomitantly larger incomes and will be interpreted as an important positive project impact by local residents.

Chalmers and Threadgill (1981) trace the historical treatment of underutilized resources in the regulations under which the federal water resource agencies have operated. This survey is supplemented by a recent paper by Dunning (1982). These surveys make a convincing case that there has been little progress made through the mid-1970s in developing credible, operational procedures for making the necessary cost adjustments. Haveman and Krutilla (1968) pointed the way in the late 1960s to investigating the extent to which project workers could be assumed to be drawn from the

¹ The term "otherwise unemployed" will be used here to include "otherwise underemployed" resources as well.

pool of unemployed. In the absence of relevant empirical information, Haveman and Krutilla were forced in their own work to postulate assumed labor response functions.

Recent efforts by the Bureau of Reclamation (Mountain West Research, Inc., 1977) and by the Army Corps of Engineers (Institute for Water Resources, 1981 and Daville Research Associates, 1982) have helped fill the previous information void. Both water resource agencies have carried out surveys of construction workers with the objective of determining the previous employment status of the workers. Twelve projects were studied by the Bureau of Reclamation and fifty-five by the Corps of Engineers. For all of these projects, workers were questioned about the extent of their unemployment experience, if any, in the six weeks preceeding their employment on the water resource project. Of the Bureau of Reclamation Workers interviewed, about half had some unemployment experience prior to their present job and thirty percent of the total had been unemployed five or more weeks of the six week period preceeding their employment on the Bureau project. This indicated that the unemployment reported by the workers was not just that associated with moving from one job to another. Further analysis showed that the proportion of the workers that were previously unemployed coming from a given area was a positive function of the unemployment rate in the region (Mountain West Research, Inc., 1977).

The surveys of Corps projects came to similar conclusions (Institute for Water Resources, 1981). They found that about forty percent of the workers had some unemployment experience in the six week period preceeding their employment on the Corps project. Additional adjustments were made to delete seasonal and discretionary unemployment. This yielded an overall estimate of otherwise unemployed workers of about 25 percent of the workforce. As with the Bureau of Reclamation study, higher rates of unemployment in the regional economy led to higher proportions of local, as opposed to non-local, labor and to more workers with prior unemployment experience.

The Institute for Water Resources (IWR) subsequently carried out further investigations of the relationship between local labor market conditions and the hiring of otherwise unemployed labor. This research confirmed the empirical relationship between regional unemployment rates and the use of previously unemployed workers, however, the research showed that the relationship is complicated by many structural features of the local economy. Based on regularities in the data, IWR recommends a procedure for calculating employment impacts based on average numbers of otherwise unemployed

workers after adjusting for skill class of worker, local/nonlocal source of worker, and the local unemployment rate.

There are two remaining problems with this approach which are noted in the literature and well recognized by IWR. First, as pointed out by Eckstein (1958, pp 51-53) and as reemphasized by Eply and Gibson (1974), the appropriate test is the employment status of the workforce "with" as compared to "without" the project. That is, the issue is not that the workers were unemployed prior to the project but whether they would have remained unemployed in the absence of the project. A related issue is whether the employment status of a worker in a brief period (six weeks) prior to a project is appropriate for generalizing to a measure of average annual impact.

Second, as was recognized by Krutilla and Haveman (1968, p. 70), it is not sufficient to look only at direct absorption of the unemployed, since an equivalent effect (i.e., no lost output) can be achieved if previously employed persons assume project jobs, but their jobs are in turn assumed by otherwise unemployed resources. Employment impacts due to this phenomena will be referred to below as replacement employment impacts.

The research reported in the remainder of this document focuses on the two issues identified above. As the employment response to a water resource development project is examined, a more realistic model of labor market adjustment may be required. In particular, an individual's contribution to national income over the course of a year is affected by a variety of seasonal, cyclical and secular factors. There may be multiple jobs, multiple spells of unemployment, differential opportunities for overtime, strikes, bad weather, etc. All of these factors combine to determine the opportunity cost associated with employing a worker on a water resource project. Further, this same complex of factors all interact to determine opportunity costs (potential impacts) as job opportunities trickle-down through the local labor market. It is difficult, therefore, to generalize about employment impacts based on a single observation of labor force status immediately preceeding employment. The next section presents the conceptual framework pursued in this study to deal with these complexities, both in the measurement of direct and replacement employment impacts.

It is important to be clear at the outset that the employment impacts under discussion here relate to the fuller utilization of labor that may result from a public

works project. This is to be distinguished from more conventionally discussed secondary or indirect employment effects which result from the expenditure of income by project employees. These, so-called multiplier effects, occur in addition to the replacement impacts that are the subject of this research.

2.0 Conceptual Framework and Approach

2.1 Direct Employment Impacts

Suppose a construction worker may expect to earn \$24,000 in his first year of employment on a Corps project. Under the traditional full-employment assumption of cost-benefit analysis, it is assumed that the \$24,000 of national income generated in the project can only be produced at the expense of an equivalent amount of income earned elsewhere in the economy. That is, since labor is fully utilized, the increased income generated in Corps construction is matched elsewhere by an equal decrease in income in the sector from which the Corps worker was drawn. Clearly, to the extent that the Corps worker was previously underutilized (i.e., unemployed, not in the labor force, or working at less than full capacity) the opportunity cost of the Corps employment will not be the full \$24,000. If this is the case, a net employment impact is generated. We shall refer to this kind of a impact as a direct employment impact.

Conceptually, direct employment impacts equal the difference between earnings on the Corps project and earnings that would have occurred had the Corps project not hired the worker. Operationally, a means must be devised of estimating earnings in the absence of the Corps project. Earnings of the worker in the year prior to Corps employment is a reasonable base for this estimate. This accounts for spells of unemployment, periods out of the labor force, and the extent to which the worker may have been underutilized. Labor utilization is clearly not simply a matter of being employed or unemployed. Over the course of a year, a worker may have multiple spells of unemployment and one or more jobs with differing levels of utilization—both in terms of the amount of work and the nature of the work. Further differences in utilization may stem from weather, strikes, personal illness, or any number of other causes. The result is that a reasonable measure of utilization must summarize a worker's experience over a period of time.

Assuming factor and product market conditions are sufficiently competitive that wages reflect labor's marginal contribution to the value of output, average annual earnings summarizes the diverse factors influencing labor utilization. Suppose, for example, one worker earned \$20,000 in the reference year while another only earned \$10,000. We would draw the inference that employing the first worker would have twice the opportunity cost of employing the second. It doesn't matter whether the differential

is due to the fact that the first worker has two jobs, or the second was unemployed for six months, or simply that the job of the first was higher paying.

Assuming that previous year earnings are taken as a measure of earnings without the project, two additional adjustments should be considered. First, it is necessary to inflate prior year earnings to account for general price inflation. Second, it may be desirable to make an adjustment for changes in regional labor market conditions. That is, if there has been a substantial deterioration in labor market conditions as measured by regional unemployment, it may be unrealistic to extrapolate prior years earnings as a measure of "without" project conditions. Rather, prior earnings may have to be adjusted down to reflect the generally lower level of labor utilization in the economy.

For example, suppose that a Corps worker earns \$24,000 in year "t", his first year on the job. Further, his annual earnings in "t-1" were \$15,000. Annual inflation from "t-1" to "t" was 10 percent and the regional unemployment rate rose from 8 to 10 percent. Direct employment impacts would be calculated as follows. First, earnings in "t-1" must be made comparable to those in "t". Inflating \$15,000 by 10 percent gives earnings of \$16,500. Thus, an initial estimate of direct employment impacts is \$7,500, the difference between the monetary cost of the worker (\$24,000) and his true, economic cost (\$16,500).

Typically, as explained above, it will not be possible to know the source of the earnings differential. It may be related to unemployment, lower utilization in another job, fewer opportunities for overtime, or any of a number of other possibilities. It is difficult to know, therefore, an appropriate adjustment in light of changed unemployment conditions. Since the unemployment rate has risen 25 percent from 8 to 10 percent, we can assume that \$7,500 would be a minimum estimate of employment impacts. If it were assumed that underutilization of labor would have increased by the same 25 percent, in the absence of the Corps project, then \$9,375 could be offered as an estimate of impacts. In fact, this is probably the maximum impact that could occur. Because of the difficult, and necessarily arbitrary nature of the adjustment for changed employment conditions, it may be preferable to not try to make this adjustment. If unemployment rate changes are modest, the resulting estimates of employment impacts should not be biased. If unemployment rates rise rapidly, however, it must be recognized that the resulting impact estimate is conservative. On the other hand, if unemployment rates are falling, impact may be overstated.

2.2 Replacement Employment Impacts

The direct employment impacts identified above may underestimate total employment impacts because replacement effects have not yet been considered. That is, the \$16,500 of income identified previously will only be foregone under the assumption that the worker presently employed with the Corps is not replaced in his previous job. If he is replaced, the potential exists for further employment impacts, due to unemployment or underutilization of the replacement worker that would have occurred in the absence of the Corps project. These impacts will be referred to as first round replacement impacts.

In order to estimate replacement impacts, three major pieces of information must be known. First, will replacement occur? If so, what will be the earnings of the replacement worker in the new employment (i.e., due to the Corps project) compared to earnings that would have been made in the absence of the project? Finally, how long does the replacement process take? Since income is a flow concept, if the replacement process takes a year, then the \$16,500 is truly lost. If the replacement process takes less than one year, the potential exists for first and perhaps subsequent round replacement impacts.

For purposes of example, suppose the Corps worker was previously employed in the manufacturing sector. Further, suppose there is growth in employment in the manufacturing sector in the region in question leading to the conclusion that replacement is probable. Replacement is assumed to take a total of one month. Average earnings of new entrants to the manufacturing sector would then be compared to estimated earnings had they not entered the manufacturing sector. Suppose average earnings of new entrants to the manufacturing sector can be expected to be \$1,200 per month. Further, assume that prior earnings of manufacturing entrants average \$1,000 per month. Assuming these estimates are in comparable dollars, the only remaining adjustment is for unemployment. The significant issue here is whether there are differential unemployment experiences by industrial sector. Suppose that new manufacturing entrants average 11 months per year of employment while workers in the sector from which these workers are drawn only average 10.5 months of employment per year. Earnings in manufacturing are, therefore, expected to be \$13,200, while, had the Corps project not materialized, earnings would only have been \$10,500. Thus, employment impacts would total \$2,700 for twelve months or \$2,475 for the eleven month period that

remained after replacement had actually occurred. Therefore, first round replacement impacts are \$2,475 due to the particular Corps employee in the example.

Second round replacement impacts would be calculated in exactly the same way. We would be examining replacement in the sector from which the manufacturing worker was drawn. If replacement here was also assumed to require one month, 10/12 of the estimated earnings differential could be counted as a second round replacement impact. Replacement impacts would cease to exist once the cumulative replacement lag totaled 12 months.

2.3 Information Requirements to Estimate Direct and Replacement Employment Impacts

The conceptual framework outlined above suggests that direct employment impacts can be estimated by comparing annual earnings during the first year of Corps employment with annual earnings in the year prior to Corps employment provided an adjustment is made for any difference in price level in the two years.

Estimation of first round replacement impacts requires that the prior industry of the Corps workers be known. It will then be necessary to have an intersectoral mobility matrix which shows the probability that a new entrant to sector "j" came from sector "k".

INTERSECTORAL MOBILITY MATRIX

From sector k = 1, . . . , 10	To sector j = 1, . . . , 9					
	1. AGR	2. MINING	.	.	.	9. GOVT
1. AGR	M1,1	M1,2	.	.	.	M1,9
2. MINING	M2,1	M2,2	.	.	.	M2,9
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
9. GOVT						
10. NOT EMPLOYED	M10,1	M10,2	.	.	.	M10,9
SUM	1.0	1.0				1.0

The column sums for the intersectoral mobility matrix would equal 1; i.e.

$$M_{kj} = 1 \quad \text{for each } j.$$

The column for mining, for example, would show the percent distribution for the sectors from which new entrants to mining originated.

Using the intersectoral mobility matrix, for example, it will be possible to estimate the sector from which a new entrant to manufacturing is likely to have come. The other major information requirement to calculate replacement impacts is an intersectoral earnings differential matrix. This matrix would be the same dimension as that described above. Each element would show the earnings differential for a new entrant to sector "j" coming from sector "k". The entries would be adjusted to reflect both differences in average earnings per hour and average annual hours by sector. They would reflect, therefore, the average annual earnings differential associated with moving from any given sector to any other.

INTERSECTORAL EARNINGS MATRIX

From sector k = 1, . . . , 10	To sector j = 1, . . . , 9					
	1. AGR	2. MINING	.	.	.	9. GOVT
1. AGR	E1,1	E1,2	.	.	.	E1,9
2. MINING	E2,1	E2,2	.	.	.	E2,9
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
9. GOVT	E9,1	E9,2	.	.	.	E9,9
10. NOT EMPLOYED	E10,1	E10,2	.	.	.	E10,9

Finally, it is necessary to have an estimate of the replacement lag as the replacement process moves from one sector to the next. With the two intersectoral matrices and an estimate of the replacement lag, each round of replacement impacts can be calculated. Employment impacts will occur where there are positive intersectoral earnings differentials. The largest will occur where an employee is drawn from the "not employed" category.

2.4 Approach

The objective of the research carried out in this study is to determine the feasibility of estimating replacement employment impacts. The research plan is to use two case studies as an integral part of the approach. Based on the conceptual frameworks outlined above, surveys were carried out at two construction sites to gather the required information to estimate impacts. Section III of this report describes these surveys and presents relevant information on the construction work force at each site. Section IV then reports on the use of this information to calculate employment impacts at the case study sites. This not only requires use of the survey data, but, as explained in Section 2.3. above, requires intersectoral mobility and earnings matrices and estimates of the replacement lag. Section IV explains the derivation of these additional pieces of required data. Direct and replacement employment impact estimates are then presented for the two case study sites.

Based on the case study results reported in Section IV, a set of procedures are examined for the estimation of impacts that would be operational for anticipatory studies for which no survey would be possible. Section V presents these recommended procedures. The procedures are then evaluated by implementing them for the two case study sites in the assumed absence of survey data. The resulting impact estimates are compared to the survey based estimates in Section IV and an overall evaluation is made of the recommended procedures.

The findings of the research and our overall conclusions are then presented together with recommendations for future research.

3.0 Case Study Surveys

This section presents findings from the on-site investigations of two Corps projects presently under construction. The purpose for the on-site surveys was to provide the information necessary to empirically verify results of the employment impact estimation model and to formulate the criteria to judge the applicability of the case study procedures to other Corps projects.

Immediately following is an overview of the methodology employed to gather the information. Topics discussed in Section 3.1 include: survey instrument design; pre-test survey findings; survey administration procedures; and data preparation and processing.

3.1 Methodology

To measure the direct and replacement employment impacts of the two Corps construction projects, specific data elements were required. The information needs are summarized below:

- Date started employment;
- Principal occupation on Corps project;
- Number of weeks unemployed in first year's employment on Corps project;
- Average weekly take home pay;
- Occupation and industry in year prior to Corps employment;
- Number of weeks unemployed in year prior to Corps employment;
- Average weekly take home pay (prior year); and
- Unemployment status the six weeks immediately preceeding Corps construction job start-up date.

After serious consideration of alternative methods to secure the data elements listed above, it was decided direct questioning of construction workers would be optimal. Weekly payroll records and other secondary information kept by Corps district personnel may have utility in verifying the survey findings, but are not a substitute for direct questioning of Corps workers.

3.1.1 Survey Instrument

A survey instrument was designed and pre-tested for overall effectiveness. The questionnaire form is presented in Figure 3-1. The form was printed on 5½ by 8½ inch cards for ease of handling.

As shown in Figure 3-1, each side of the card refers to a different point in time. The first side (top half of the questionnaire) is concerned with the initial 12-month period of employment on the Corps construction project. The second side (bottom portion of Figure 3-1) deals with the 12-month period of time prior to the worker's employment on the Corps project. Question 1 is designed to provide information on the respondent's current project employment start-up date, and to help guide the respondent's frame of reference to his/her initial 12-month period of employment versus his/her current employment on the Corps project. Question 2 concerns the respondent's occupational classification on the Corps job. Occupational information will be valuable to sensitivity test the survey results and to judge the conformability of this study with previous studies which have been conducted in the area. The third question is designed to measure the respondent's unemployment history over a year's period. Question 4 asks for the typical weekly take home pay during the period of time in which the construction worker was actually working. The two points of information derived from questions 3 and 4 will be used to compute the respondent's annual earnings.

Side 2 of the questionnaire pertains to the 12-month period prior to starting work on the Corps project. Review of the employment and earnings data in the year prior to Corps employment will form the basis for measuring the direct employment impacts of the project in that these variables serve as a proxy measure for what the earnings of the worker would have otherwise been had he/she not been employed on the Corps project.

Questions 5 and 6 address the worker's prior occupation and industrial sector of employment. The industrial sector of origin information can be used to validate the Current Population Survey (CPS) data which form the basis of the intersectoral mobility and intersectoral earnings differential matrices. The information can also be used to identify first round replacement impacts as the sector is identified which was vacated by the respondent in order to work on the Corps construction project.

FIGURE 3-1

SURVEY QUESTIONNAIRE FORM

PLEASE DO NOT PLACE YOUR NAME ON THIS SURVEY FORM.

Hello. The information obtained from this short questionnaire will be used to develop information about how U.S. Army Corps of Engineers projects generate employment opportunities. The information contained in this survey will remain confidential. Thank you for your help and cooperation.

1. When did you start working on this project?

Month _____
Year _____

The remainder of this side of the card contains questions about your first year of employment on this project. If you have worked less than one year on this project, answer the questions based on the time you have worked.

2. What was your principal occupation (job title) during your first year (or part year) of employment? _____
3. Were there any weeks you did not work due to weather, strike, temporary layoff, etc. during your first year (or part year) of employment on this project?
(Circle one) YES NO
If YES, approximately how many weeks were you not working in all? _____ weeks.
4. During your first year (or part year) of employment on this project, what was your usual weekly take home pay? \$ _____ week.

PLEASE TURN TO THE OTHER SIDE OF THIS CARD

This side of the card contains questions about the year before you started working on this project.

5. What was your principal occupation (job title) in the year before you started to working on this project? _____
6. During the year before you started working on this project what business was your principal employer in? _____
7. Were you out of work at any time during the year before you started to work on this project? (Circle One) YES NO If yes, approximately how many weeks in all? _____
8. During the year before you started working on this project, what was your usual weekly take home pay? \$ _____ weekly.
9. Were you unemployed at any time during the six weeks just before you started work on this project? (Circle one) YES NO If yes, approximately how many days were you unemployed during that six week period? _____ days.

THANK YOU AGAIN FOR YOUR COOPERATION

Questions 7 and 8 provide information to formulate average annual earnings which, when adjusted, can be compared with Corps project earnings to measure direct and replacement employment impacts. The final question is designed to measure the relationship of employment immediately preceeding project employment to average unemployment over the previous year.

3.1.2 The Pre-test Survey

A pre-test was administered to test the questionnaire form and to develop procedural guidelines for survey administration at the two case study locations. The pre-test was administered at the U.S. Army Corps of Engineers Skunk Creek, Arizona channelization and levee project. The survey site is located in Maricopa County, Arizona, just west of the City of Phoenix. The Skunk Creek channelization and levee project consists of construction of flood control levees and channelization of the creek. Project construction started in April 1982 and is expected to be completed by April 1983. One prime contractor and one subcontractor are responsible for the performance of work. Construction workers under the prime contractor are performing the concrete work for portions of the channel and the pier extensions. Those working under the subcontractor are primarily heavy equipment operators and are responsible for excavating the channel and building the levees.

Copies of the survey instrument were distributed to the prime and subcontractors by the Corps of Engineer field supervisor and a Mountain West Research-Southwest, Inc. (MWR-SW) representative. The prime and subcontractors were, in turn, responsible for seeing that their workers completed the questionnaire form. The prime and subcontractors returned the completed questionnaires to the Corps field supervisor who, in turn, returned the forms to MWR-SW. Upon review of the completed questionnaires it appeared the construction workers understood the questions and could answer them in a consistent and logical manner. Further, from the pre-test survey, a set of guidelines for the survey administration procedure were more clearly defined.

3.1.3 Survey Administration

The Institute of Water Resources (IWR) contracting officer made initial contacts with key Corps district personnel at the case study locations. Next, the Corps district personnel were asked to contact the prime contractors on the project to inform them of the survey and the need for their cooperation. Once the necessary contacts were made, a travel agenda was prepared. Time for discussion with Corps supervisory personnel and

the construction contractors was scheduled on the agenda. Also scheduled was time to review secondary information such as weekly payroll reports and Davis-Bacon wage contracts.

The survey administration procedure ultimately employed was not the same at the two survey sites. Viable alternatives considered, however, were: insertion of survey forms into employee pay envelopes, distribution of survey forms at mandatory safety meetings, or field distribution of questionnaires by supervisory or MWR-SW personnel. Sections 3.2 and 3.3 discuss the survey administration procedures used at each case study location.

3.1.4 Data Preparation and Processing

One MWR-SW analyst coded and reviewed the completed survey forms to assure consistency in approach and response. In instances where responses were out of the range of feasible possibilities the data were edited accordingly. The coded survey forms were key punched and verified by professional data processors. Using a computer software package, descriptive information about the characteristics of the work force was generated. This information is presented in Sections 3.2 and 3.3 with a description of the Lakeview, Texas and L & D 26 (St. Louis) case study projects.

3.2 Lakeview Lake, Mountain Creek Texas, Fort Worth District **United States Army Corps of Engineers**

The Lakeview Lake project is a flood control earth filled dam. The site is located approximately 15 miles south of the Dallas-Fort Worth International Airport. The dam is being constructed as a flood control measure to prevent inundation damages in nearby residential areas.

3.2.1 Detailed Project Description

Construction of the earth-filled dam involves six stages. First, the acquisition of land for the actual dam site and surrounding area was required. Next the initial embankment and outlet works were constructed. The third stage involved relocation of utility lines such as gas, water, and streets and roads in the project vicinity. The fourth stage required the completion of the embankment and spillway while continuing with the relocation of utility lines. The project was in this fourth phase at the time of the survey. Once construction of the embankment and spillway is complete, trees and other

debris must be cleared from the lake. The final stage involves the construction of recreational amenities such as sanitary and safety facilities, the boat ramp, and rest room areas.

The construction workforce is non-union and involves the following trades: equipment operators, concrete finishers, iron workers, laborers, mechanics, and truck drivers.

Supervisory personnel from the three major construction contractors indicated from 70 to 80 percent of their workforce is from the local region. Additionally, supervisory personnel indicated most all of their workers came from the construction industry prior to employment on the Corps project. Although the major portion of their workforce came out of the construction industry, one contractor indicated many people were taught to use more sophisticated equipment thereby upgrading their occupational skills.

Administrative personnel indicated the Lakeview Dam project is attractive compared to other construction projects due to the site location, low labor force turnover, and low frequency in disruptions in the performance of work due to strikes. Work stopages due to weather have been a problem, however.

The project site is located nearly the same distance from Dallas and Fort Worth, taking approximately 40 minutes to reach from either location. Access to the site from Dallas and Fort Worth is on interstate and state highway routes except that the last 3 miles require travel on a slower moving, two lane road. This close proximity to the metropolitan area is viewed favorably by supervisory staff and workers alike, especially when one considers that many of the major public works construction projects in this region of the country are generally located in more remote areas.

The labor turnover rate since the beginning of the fourth phase of construction has varied among subcontractors and is largely dependent on the task to be performed. For example, the contractor who is in charge of moving refuse from a sanitary landfill has experienced 100 percent turnover. The contractor responsible for completion of the embankment, spillway, and outlet work, however, has experienced a much lower turnover rate of 25 percent, while the team in charge of street and utility relocations has experienced a turnover rate of just 10 percent. An advantage of this project is the

opportunity for a relatively long term employment experience of 3 to 4 years. Those contractors who have experienced low turnover suggested that the attractive site location and present unstable economic conditions have resulted in increased workforce stability.

Work stoppages due to weather represent the least desirable feature of the project. From May 1982 to the survey period October 1982, construction had been interrupted 40 to 50 days because of rain. The stoppages are viewed negatively by workers because they do not collect pay during these periods, and also by supervisory personnel because the days represent setbacks in their projected completion schedules.

3.2.2 Survey Approach—Lakeview Dam Project, Texas

Key personnel from the U.S. Army Corps of Engineers Fort Worth District were contacted by the IWR, to inform them of the survey and to solicit their cooperation in administration of the survey instrument. Based on the Fort Worth District's positive response a MWR-SW representative contacted the Lakeview dam project's resident engineer and explained in more detail the nature of the study. A survey administration procedure was determined with the resident engineer which would be most appropriate given the working conditions at the project site. The procedure entailed distributing the questionnaire forms at the weekly safety meetings. The Corps field engineer, with the support of the construction contractors, arranged to reschedule the workers' weekly safety meetings so that the Corps field representative and MWR-SW analyst could personally circulate the survey forms among the construction workers. The percentage of workers surveyed was 47.3 percent and was a high percentage of the total number of workers in attendance at the safety meetings on the two survey days. Survey results are summarized in the following section.

3.2.3 Survey Findings—Lakeview Dam Project, Texas

What follows is a summary of the characteristics of the construction labor force at the Lakeview dam project. Table 3-1 identifies the present occupation of the workforce by class of worker (i.e., skilled, unskilled, and white collar).

As shown in Table 3-1, nearly 82 percent of the construction workforce were skilled and 18 percent were classified as unskilled. As could be expected, none of the workers surveyed held white collar positions. Table 3-2 provides a more detailed breakdown of the occupational classifications of the construction workers. The largest

single percentage of respondents surveyed, 37.3 percent, were equipment operators, followed by laborers at 18.3 percent. The nonresponse rate to this question was fairly high at 9.2 percent. It is interesting to compare Table 3-1 with Table 3-3, the previous occupation of the construction workforce by class of worker. As shown, 77.5 percent of the respondents were skilled workers the year prior to employment on the Corps project compared to 12.7 percent unskilled workers. Table 3-3 also indicates 4.2 percent of the respondents were in white collar occupations such as restaurant manager, cashier, clerk, the year prior to employment on the Corps project and 5.6 percent were unemployed.

TABLE 3-1
PRESENT OCCUPATION OF WORKFORCE BY SKILL CLASSIFICATION
LAKEVIEW, TEXAS SURVEY SITE

Skilled Level	Number of Respondents	Percent of Total
Skilled	116	81.7
Unskilled	26	18.3
White Collar	<u>0</u>	<u>0.0</u>
TOTAL	142	100.0

Source: Mountain West Research-Southwest, Inc., 1982

Most of the respondents were recent employees on the job as over 66 percent started work on this project as late as August, September, and October (Table 3-4). Additionally, since becoming employed over 43 percent reported no disruptions in their employment tenure. Close to 15 percent of the respondents, however, reported that work disruptions, mainly due to bad weather, accounted for 10 to 20 percent of their total employment tenure. An additional 12.7 percent indicated 20 to 30 percent of their total length of employment on the Corps project was spent in time for which they were unable to work. These results are summarized in Table 3-5. The fact that the percentage of weeks not worked varied across respondents is not unusual as each respondent's employment start-up date on the project varied. Further, weather conditions impact each contractor in a different fashion—some are able to work in bad weather and others are not. A weighted average of the results in Table 3-5 implies average under-utilization of 9.2 percent.

TABLE 3-2**PRESENT OCCUPATION OF WORK FORCE
LAKEVIEW, TEXAS SURVEY SITE**

Occupation	Number of Respondents	Percent of * Total
Soils Lab Technician	1	.7
Surveyor	3	2.1
Carpenter	11	7.7
Cement Worker	5	3.5
Equipment Operator	53	37.3
Field Engineer	7	4.9
Mechanic	3	2.1
Finisher	1	.7
Strander	6	4.2
Rod Man	2	1.4
Oiler	3	2.1
Laborer	26	18.3
Teamster/Truck Driver	5	3.5
Equipment Manager	1	.7
Parts and Warehousing	2	1.4
No Response	<u>13</u>	<u>9.2</u>
TOTAL	142	99.8

* Totals may not sum to 100 percent due to rounding.

Source: Mountain West Research-Southwest, Inc., 1982.

TABLE 3-3

**PREVIOUS OCCUPATION OF WORKFORCE BY SKILL CLASSIFICATION
LAKEVIEW, TEXAS SURVEY SITE**

Skill Level	Number of Respondents	Percent of Total
Skilled	110	77.5
Unskilled	18	12.7
White Collar	6	4.2
Unemployed	<u>8</u>	<u>5.6</u>
TOTAL	142	100.0

Source: Mountain West Research-Southwest, Inc. 1982.

TABLE 3-4

**EMPLOYMENT START-UP DATE (MONTH)
LAKEVIEW, TEXAS SURVEY SITE**

Month	Number of Respondents	Percent of * Total
March	2	1.4
April	8	5.6
May	3	2.1
June	8	5.6
July	17	12.0
August	35	24.6
September	31	21.8
October	28	19.7
No Response	<u>10</u>	<u>7.0</u>
TOTAL	142	99.8

* Totals may not sum to 100 percent due to rounding.

Source: Mountain West Research-Southwest, Inc., 1982.

TABLE 3-5**PERCENTAGE OF TOTAL WEEKS NOT WORKING WHILE EMPLOYED ON CORPS PROJECT
LAKEVIEW, TEXAS SURVEY SITE**

Percentage of Weeks Not Worked	Number of Respondents	Percent of Total
0% (i.e., worked entire period)	62	43.7
1 to 10%	5	3.5
10 to 20%	21	14.8
20 to 30%	18	12.7
30 to 40%	4	2.8
40 to 50%	2	1.4
50 to 60%	0	0.0
60 to 70%	0	0.0
70 to 80%	1	.7
80 to 90%		
90 to 100%	3	2.1
No Response	<u>26</u>	<u>18.3</u>
TOTAL	142	100.0

Source: Mountain West Research-Southwest, Inc., 1982.

The findings in Table 3-5 can be compared with Table 3-6 which provides information on the percentage of weeks not worked in the year prior to employment on the Corps project. Review of the Table 3-6 indicates nearly 53 percent of the respondents were employed the entire portion of the year prior to their Corps project employment. The next largest percentage of respondents, 17.6 percent, indicated they did not work up to 10 percent (just over 5 weeks) of the prior year, followed by 12 percent who reported to have not worked 10 to 20 percent of the weeks in the year previous to their employment on the Corps project. It is interesting to note, 5.6 percent of the respondents indicated they were out of work from 90 to 100 percent of the previous year. This finding is consistent with the results in Table 3-3 and may indicate that the Corps construction project provided employment opportunities for a group who would otherwise have been unemployed. The weighted average of the results in Table 3-6 implies average under-utilization of 10.6 percent.

Survey findings suggest some intersectoral shifting is taking place. The figures in Table 3-7 show nearly 19 percent of the survey respondents were employed in an industrial sector different than construction. The largest single percentage, 5.6 percent, came out of the service sector, followed by 4.2 percent from transportation, communications, and public utilities; 3.5 from trade; and 2.1 from manufacturing. As expected, the majority of workers, 71.8 percent, were employed in the construction industry prior to their employment on the Corps project.

The information presented in Table 3-8 was generated to give further insight into the relationship between average under-utilization and unemployment immediately preceeding employment. IWR has used 10 days of unemployment as a reasonable period of time for "discretionary unemployment", where workers are considered to be "on vacation" or between jobs, etc. Eleven days, however, are hypothesized to represent a condition of a more prolonged state of involuntary unemployment. Review of Table 3-8 indicates 28.1 percent of the respondents would be considered unemployed using the eleven day definition.

3.3 The Lock and Dam (L & D) No. 26 — St. Louis District **United States Army Corps of Engineers**

The L & D 26 project consists of construction of a non-navigable gated dam with a single medium lift navigation lock. It is located on the Mississippi River (mile 200.78),

TABLE 3-6

**PERCENTAGE OF WEEKS NOT WORKED YEAR PRIOR TO CORPS PROJECT EMPLOYMENT
LAKEVIEW, TEXAS SURVEY SITE**

Percentage of Weeks Not Worked	Number of Respondents	Percent of * Total
0% (i.e., worked entire period)	75	52.8
1 to 10%	25	17.6
10 to 20%	17	12.0
20 to 30%	4	2.8
30 to 40%	2	1.4
40 to 50%	3	2.1
50 to 60%	1	.7
60 to 70%	0	0.0
70 to 80%	1	.7
80 to 90%	0	0.0
90 to 100%	8	5.6
No Response	<u>6</u>	<u>4.2</u>
TOTAL	142	99.9

* Totals may not sum to 100 percent due to rounding.

Source: Mountain West Research-Southwest, Inc., 1982.

TABLE 3-7**INDUSTRIAL SECTOR OF EMPLOYMENT PRIOR TO EMPLOYMENT ON CORPS PROJECT
LAKEVIEW, TEXAS SURVEY SITE**

Industrial Sector	Number of Respondents	Percent of * Total
Agriculture, Forestry, and Fisheries	1	.7
Mining	2	1.4
Construction	102	71.8
Manufacturing	3	2.1
Transportation, Communications, and Public Utilities	6	4.2
Trade	5	3.5
Finance, Insurance, and Real Estate	0	0.0
Services	8	5.6
Government	2	1.4
Unemployed	8	5.6
No Response	<u>5</u>	<u>3.5</u>
TOTAL	142	99.8

* Totals may not sum to 100 percent due to rounding.

Source: Mountain West Research-Southwest, Inc, 1982.

TABLE 3-8

**NUMBER OF DAYS NOT WORKED DURING THE SIX WEEK PERIOD
PRIOR TO CORPS EMPLOYMENT
LAKEVIEW, TEXAS SURVEY SITE**

Days Not Worked	Number of Respondents	Percent of Total
0 (i.e., worked entire period)	86	60.6
1	1	.7
2	2	1.4
4	2	1.4
5	1	.7
6	2	1.4
8	2	1.4
10	1	.7
12	1	.7
14	5	3.5
15	1	.7
17	1	.7
18	1	.7
21	1	.7
25	1	.7
28	2	1.4
30	5	3.5
42 *	22	15.5
Improper Response	<u>5</u>	<u>3.5</u>
TOTAL	142	99.9

* The 6 week period was designed to represent 30 working days. In the construction industry however, a 5 day work week is not necessarily standard, as such, responses of 42 days were provided and are assumed to be valid responses for this analysis.

two miles downstream from the existing L & D 26 near the city of Alton, Illinois. This is about 15 miles downstream of the Illinois River, 8 miles upstream of the Missouri River and approximately 35 miles north of St. Louis, Missouri. The replacement lock and dam are necessitated due to the heavy flow of river traffic which is not currently being accommodated by the present structure; and the intermittent foundation problems and lateral and vertical movement of the current lock and dam structures.

3.3.1 Detailed Project Description

Construction of the new Lock and Dam 26 will be carried out in three phases. Phase I involves three distinct work tasks. First, the bankline of the Mississippi River must be cut back with stone protections placed to line the banks. Next a cofferdam which will allow work to be conducted in the river bed will be constructed. Construction of the cofferdam is a large undertaking consisting of 45 cylindrical cells, 60 feet in diameter formed of 10,000 interlocking steel sheet piles which are driven into the river bottom. The cofferdam is made by filling the cells with material which forms a solid protective wall. The construction of the first $6\frac{1}{2}$ gate bays for the main dam structure will also be in Phase I. It is estimated this phase would take $2\frac{1}{2}$ years to complete. At the time of the survey, construction in this first phase was still underway.

Phase II involves construction of another $\frac{1}{2}$ gate bay on the dam and construction of the lock. A second cofferdam must be built to complete this phase of work. It is estimated that this phase will take $3\frac{1}{2}$ years to complete.

Phase III consists of a two gate bay dam section and a closure structure between the lock and the Illinois shore. Construction of a cofferdam will also be necessary for this phase of construction. It is estimated this phase will take 2 years to finish—targeting overall project completion for January 1989.

The construction workforce is made up entirely of union represented personnel. Locals on the job include The Construction, Laborers, and the Hod Carriers Local 218; Carpenters' District Council of Madison County and Vicinity; Cement Masons Local 90; Ironworkers Local 392; International Union of Operating Engineers; and The Teamsters Local 525.

Supervisory personnel indicated that close to 90 percent of the workforce is from the immediate region. This is a very high percentage of local workforce. Further,

supervisors indicated that most of the workers had come from the construction industry and within the same occupational classification before employment on the L & D 26 project.

Conversation with administrative personnel revealed that the L & D project is about equal in attractiveness with other construction projects in the area. The attractiveness of the L & D 26 project relative to other large scale construction projects was assessed in terms of the site location, labor force turnover, and interruptions in construction.

The L & D 26 is located within 45 minutes commute time from St. Louis, Missouri. Access to the site from St. Louis is primarily by interstate and state highway routes with the last 7 to 10 miles on a narrow two lane road. Although the site is located very close to the metropolitan area, administrative personnel said that because there is a substantial amount of construction taking place in downtown St. Louis, many workers prefer to work in the downtown area and do not appreciate the close proximity of the construction site as much as they otherwise would had employment opportunities in the immediate area been scarce.

Overall turnover during Phase I construction, at an estimated 10 percent, has been extremely low. This can be compared with the turnover rates on other public works projects undertaken in the same portion of the country of 60 to 70 percent. Supervisory personnel suggested a likely reason for the low turnover is the present state of the economy. Also, the longer term employment potential relative to other construction projects and the fact that certain crafts of workers are employed on a year round basis contribute to the low turnover.

On the downside, there have been some interruptions in project construction due to weather and strikes. It is projected that upon completion of Phase I, 121 lost days will have taken place. This is in excess of normal and is attributed to the high water stage of the river, which holds up construction of the cofferdam. Further, in May and June 1980, the operating engineers went on strike which interrupted progress on this project for 30 days. The operating engineers went on another strike in August of 1981 for 10 days. The strike did not affect the project, however, because the river was at high water, therefore, work could not have been conducted in any event.

3.3.2 Survey Approach - L & D 26 Project, Illinois/Missouri

Supervisory personnel from the U.S. Army Corps of Engineers, St. Louis District were notified of the construction worker survey by IWR. A MWR-SW representative contacted the L & D 26 project's resident engineer to explain in more detail the nature of the study and to determine with the resident engineer the most appropriate survey administration procedure. It was agreed that the prime contractor's safety engineer and personnel from the Corps resident office field staff would distribute the questionnaire forms at the workers' weekly "tool-box" safety meetings. The "tool box" safety meetings are somewhat different than regular safety meetings and consist of a number of gatherings of small groups of workers rather than a few gatherings of large groups of workers. This survey administration approach was taken mainly because Corps supervisory personnel had serious reservations about disrupting the construction worker's schedules to administer the survey, and the obvious logistical difficulty associated with any one person's presence at each "tool-box" safety meeting. Fifty-four percent of the workers on payroll were surveyed. Survey results are summarized in the following section.

3.3.3 Survey Findings - L & D Project, Illinois/Missouri

What follows is a summary of the characteristics of the construction labor force at the L & D 26 project. Table 3-9 identifies the present occupation of the work force by class of worker (i.e., skilled, unskilled, and white collar). Review of Table 3-9 indicates 79 percent of the workforce were classified as skilled, compared to nearly 20 percent who were classified as unskilled. As expected, none of the workers surveyed held white collar positions. Table 3-10 provides more detailed information concerning the occupational classifications of the workforce. The table shows that nearly 44 percent of the respondents were equipment operators. Like the Texas survey, this group represents the largest single percentage of respondents surveyed. Again, similar to the Texas case study findings, laborers made up the second largest group falling within a single occupational classification at 19.8 percent. Electricians and carpenters also shared a reasonably large portion of the sample at 11.7 and 9.3 percent, respectively. Comparison of Table 3-9 with Table 3-11 shows that the the occupational distribution of the workforce by class of worker showed no appreciable change from the year prior to employment on the Corps project to the respondent's first year's employment on the Corps project. The most notable difference is that 1.9 percent of the respondents were unemployed the entire year before they started work on the Corps project. The

TABLE 3-9**PRESENT OCCUPATION OF WORKFORCE BY SKILL CLASSIFICATION
L & D 26 PROJECT ST. LOUIS, MISSOURI**

Skilled Level	Number of Respondents	Percent of Total
Skilled	128	79.0
Unskilled	32	19.8
White Collar	0	0.0
No Response	<u>2</u>	<u>1.2</u>
TOTAL	162	100.0

Source: Mountain West Research - Southwest, Inc., 1982

TABLE 3-10**PRESENT OCCUPATION OF WORK FORCE
L & D 26 PROJECT ST. LOUIS, MISSOURI**

Occupation	Number of Respondents	Percent of Total
Carpenter	15	9.3
Electrician	19	11.7
Equipment Operator	71	43.8
Mechanic	1	.6
Structural Metal Craftsman (Iron Worker)	9	5.6
Oiler	2	1.2
Welder	3	1.9
River Pilot	1	.6
Laborer	32	19.8
Teamster	7	4.3
No Response	<u>2</u>	<u>1.2</u>
TOTAL	162	100.0

Source: Mountain West Research - Southwest, Inc., 1982

TABLE 3-11**PREVIOUS OCCUPATION OF WORKFORCE BY SKILL CLASSIFICATION
L & D 26 PROJECT ST. LOUIS, MISSOURI**

Skilled Level	Number of Respondents	Percent of Total
Skilled	121	74.7
Unskilled	33	20.4
White Collar	1	.6
Unemployed	3	1.9
No Response	<u>4</u>	<u>2.5</u>
TOTAL	162	100.1

* Totals may not sum to 100 percent due to rounding.

Source: Mountain West Research - Southwest Inc., 1982

relatively stable occupational composition can be explained largely by the fact that workers on the L & D 26 are, and have been, strictly union personnel and as a result are subject to the rigidly defined occupational/trade hierarchy established within the union institutional setting.

Many of the respondents, 13.6 percent, have been working on the project for over a year. Table 3-12 shows the largest single percentage of respondent's, 18.5 percent, have worked on the project 9 weeks, followed by 13.6 percent in both the 13 weeks and 52 or more weeks categories, and 12.3 percent at 17 weeks. Nearly 55 percent of the respondents have worked 6 months or less. Additionally, since having worked on the Corps project, over 54 percent of the respondents reported no disruptions in their employment tenure (Table 3-13). Slightly over 30 percent of those surveyed, however, reported that work disruptions due to weather and strikes accounted for up to 50 percent of their employment tenure, while just 5 percent reported disruptions in excess of 50 percent of their employment tenure. A weighted average of the results in Table 3-13 implies average under-utilization of 7.5 percent by the workers surveyed on the Corps project.

The findings in Table 3-13 can be compared with Table 3-14 which provides similar information for the year prior to employment on the Corps project. The weighted average for Table 3-14 implies under-utilization of 15.8 percent during the year prior to Corps employment. This is almost twice the level observed during the year of Corps employment.

Survey findings show very little industrial shifting is taking place. Review of Table 3-15 shows over 95 percent of the respondents were employed in the construction industry prior to their employment on the Corps project. When those individuals who were unemployed the entire year before becoming employed on the Corps project are excluded from the sample the proportion of workers coming from the construction industry increases to close to 97 percent. This finding is not unusual as the L & D 26 job is strictly union and most of the workers have retained union affiliation over a period of years. Just 2 percent of those surveyed had come from an industrial sector other than construction.

Table 3-16 presents information on the number of days a respondent experienced unemployment during the 6 week period prior to Corps project employment. Review of the table indicates 46.9 percent of the respondents would be considered unemployed based on the 11 day criterion discussed previously.

TABLE 3-12**EMPLOYMENT TENURE (WEEKS)
L & D 26 PROJECT ST. LOUIS, MISSOURI**

Weeks Worked *	Number of Respondents	Percent of Total **
4	3	1.9
9	30	18.5
13	22	13.6
17	20	12.3
22	14	8.6
26	12	7.4
30	10	6.2
34	10	6.2
39	7	4.3
43	4	2.5
47	4	2.5
52 or more	22	13.6
No response	<u>4</u>	<u>2.5</u>
TOTAL	162	100.1

* Rounded to the nearest whole week.

** Percentages may not sum to 100 percent due to rounding.

Source: Mountain West Research - Southwest Inc., 1982

TABLE 3-13

**PERCENTAGE OF TOTAL WEEKS NOT WORKING
WHILE EMPLOYED ON CORPS PROJECT
L & D 26 PROJECT ST. LOUIS, MISSOURI**

Percentage of Weeks Not Worked	Number of Respondents	Percent of Total
0% (i.e., worked entire period)	88	54.3
1 to 10%	21	13.0
10 to 20%	18	11.1
20 to 30%	4	2.5
30 to 40%	4	2.5
40 to 50%	2	1.2
50 to 60%	3	1.9
60 to 70%	1	.6
70 to 80%	0	0.0
80 to 90%	0	0.0
90 to 100%	4	2.5
No Response	<u>17</u>	<u>10.4</u>
TOTAL	162	100.0

Source: Mountain West Research - Southwest Inc., 1982

TABLE 3-14

**PERCENTAGE OF WEEKS NOT WORKED YEAR PRIOR
TO CORPS PROJECT EMPLOYMENT
L & D 26 PROJECT ST. LOUIS, MISSOURI**

Percentage of Weeks Not Worked	Number of Respondents	Percent of Total
0% (i.e., worked entire period)	48	29.6
1 to 10%	13	8.0
10 to 20%	32	19.8
20 to 30%	15	9.3
30 to 40%	9	5.6
40 to 50%	12	7.4
50 to 60%	2	1.2
60 to 70%	8	4.9
70 to 80%	4	2.5
80 to 90%	3	1.8
90 to 100%	4	2.5
No Response	<u>12</u>	<u>7.4</u>
TOTAL	162	100.0

Source: Mountain West Research - Southwest Inc., 1982

TABLE 3-15**INDUSTRIAL SECTOR OF EMPLOYMENT PRIOR
TO EMPLOYMENT ON CORPS PROJECT
L & D PROJECT ST. LOUIS, MISSOURI**

Industrial Sector	Number of Respondents	Percent of Total
Agriculture, Forestry, and Fisheries	0	0.0
Mining	0	0.0
Construction	154	95.1
Manufacturing	1	.6
Transportation, Communications and Public Utilities	1	.6
Trade	1	.6
Finance, Insurance, and Real Estate	0	0.0
Services	1	.6
Government	0	0.0
Unemployed	3	1.9
No Response	<u>1</u>	<u>.6</u>
TOTAL	162	100.0

Source: Mountain West Research - Southwest Inc., 1982

TABLE 3-16.

NUMBER OF DAYS NOT WORKED DURING THE SIX WEEK PERIOD
PRIOR TO CORPS EMPLOYMENT
L & D 26 PROJECT ST. LOUIS, MISSOURI

Days not Worked	Respondents	Percent of Total*
0	62	38.3
1	1	.6
2	4	2.5
3	1	.6
4	2	1.2
5	1	.6
6	2	1.2
7	1	.6
8	1	.6
10	4	2.5
12	2	1.2
14	7	4.3
15	3	1.9
16	1	.6
20	6	3.7
21	3	1.9
25	4	2.5
28	1	.6
30	15	9.3
32	1	.6
36	2	1.2
37	1	.6
40	2	1.2
42	28	17.3
No Response	<u>7</u>	<u>4.3</u>
TOTAL	162	99.9

* Totals may not sum to 100 percent due to rounding.

Source: Mountain West Research-Southwest, Inc., 1982

4.0 Direct and Replacement Employment Impacts at Case Study Projects

4.1 Impact Estimation Procedure

The material to follow explains the procedure employed at the case study locations to estimate employment impacts, the supplementary data elements which were needed to calculate employment impacts, and presents the direct and replacement employment impacts attributed to construction of the Lakeview Lake, Texas flood control project and the Locks and Dam 26 project located near St. Louis, Missouri.

4.1.1 Direct Employment Impact Estimation Procedure

Direct employment impacts are calculated by looking at the difference between the worker's adjusted weekly earnings multiplied by the percentage of time employed actually spent working in the worker's first or current year's employment on the Corps project (t) compared to the same factors in the year prior to Corps employment (t-1) extrapolated over a 52 week period.

To generate unbiased direct employment estimates, it is first necessary to adjust wages to a common dollar base since the earnings in the first year on the Corps project (t), and in the year prior to Corps employment (t-1), pertain to different time periods. This study used 1981 dollars as the index measure.

Once weekly earnings have been expressed in comparable units (1981 dollars), it is necessary to adjust these figures by the proportion of weeks worked in the first year on the Corps project, and the year prior to Corps project employment.

Annual direct employment impacts for the i^{th} worker can then be calculated using the following formula:

$$D_i = (WY_{i,t} \cdot WW_{i,t} - WY_{i,t-1} \cdot WW_{i,t-1}) \cdot 52$$

where:

$WY_{i,t}$ = adjusted weekly earnings of the i^{th} worker in year t;

$WW_{i,t}$ = proportion of weeks worked by the i^{th} worker in year t;

$WY_{i,t-1}$ = adjusted weekly earnings of the i^{th} worker in year t-1;

$WW_{i,t}$ = proportion of weeks worked by the i^{th} worker in year t-1.

The total direct employment impact for surveyed workers (D) is derived by summing the annual direct employment impact over all the workers:

$$D = \sum_{i=1}^n D_i$$

where

D_i = direct employment impact of the i^{th} worker; and

D = total direct employment impact.

The mean direct impact for the surveyed workers is computed by dividing the total direct employment impact by the number of workers surveyed:

$$\bar{D} = \frac{D}{N}$$

where

$\bar{D}$ = mean direct impact; and

N = number of workers surveyed.

Project direct impacts are computed by multiplying $\bar{D}$ by average annual employment over the length of the construction period.

4.1.2 Replacement Impact Estimation Procedure

The conceptual framework outlined above suggests that direct employment impacts can be estimated by comparing annual earnings during the first year of Corps employment with annual earnings in the year prior to Corps employment provided an adjustment is made for difference in price level in the two years. Estimation of replacement impacts requires, however, that the prior industry of the Corps workers be known.

Let m_{kj} be an absolute mobility matrix; i.e., a typical element $m_{r,s}$ would show the number of migrants from sector r to sector s during the sample period. The column sums show the total number of workers moving to a given industry, while the row sum shows the total number of workers moving from an industry.

ABSOLUTE MOBILITY MATRIX

		To Sector j=1,...,9						Σ
		1. AG	2. Mining	3. Constr.	.	.	9. Govt.	
From Sector k=1,...,10	1. AG.	m_{11}	m_{12}	m_{13}	.	.	m_{19}	m1.
	2. Mining	m_{21}	m_{22}	m_{23}	.	.	m_{29}	m1.
	3. Constr.	m_{31}	m_{32}	m_{33}	.	.	.	m3.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	$M_{r,s}$	.	.
	.	.	.	.	.	.	.	.
	9. Govt.	m_{91}	.	.	.	.	.	.
	10. Not Emp.	$m_{10,1}$	.	$m_{10,9}$	.	.	.	.
	Σ	m.1	m.2	m.3	.	.	.	

The intersectoral mobility matrix is then constructed by dividing through each element of the absolute mobility matrix by its corresponding column sum. A typical element, M_{rs} , shows the probability that an entrant to sector s came from sector r. The intersectoral mobility matrix is, therefore, a matrix of probabilities that allows a group of entrants to any given sector to be distributed back to their sector of origin.

INTERSECTORAL MOBILITY MATRIX

		to sector j=1,...,9			
		1. AG.	2. Mining	.	9. Govt.
from sector k=1,...,10	1. AG.	$M_{11}=m_{11}/m \cdot 1$	$M_{12}=m_{12}/m \cdot 2$	.	$M_{19}=m_{19}/m \cdot 9$
	2. Mining	$M_{21}=m_{21}/m \cdot 1$	.	.	.
	3. Const.	$M_{31}=m_{31}/m \cdot 1$	.	.	.
	.	.	.	.	.
	.	.	$M_{rs}=M_{r,s}/m \cdot s$	.	.
	.	.	.	.	.
	9. Govt.	$M_{91}=m_{91}/m \cdot 1$	.	.	.
	10. Not Emp.	$M_{10,1}=m_{10,1}/m \cdot 1$	.	.	.
	Σ	1.0	1.0	.	1.0

The second construct necessary to estimate replacement impacts summarizes the potential earnings differential associated with moving from one sector to another. We will define E_{kj} to be an annualized Intersectoral Earnings Differential matrix. A typical element, E_{rs} shows the difference in average annual earnings (in 1981 dollars) associated with a move from sector r to sector s . If E_{rs} is positive, it implies that an entrant to sector s from sector r will experience an increase in average annual earnings.

INTERSECTORAL EARNINGS DIFFERENTIAL MATRIX

		To Sector $j=1,...,9$					
		1. AG	2. Mining	3. Constr.	.	.	9. Govt.
From Sector $k=1,...,10$	1. AG.	E_{11}	E_{12}	E_{13}	.	.	E_{19}
	2. Mining	E_{21}	E_{22}	E_{23}	.	.	m_{29}
	3. Constr.	.	.	.	.	.	.
	.	.	.	.	.	.	.
	.	.	.	.	.	E_{rs}	.
	.	.	.	.	.	.	.
	9. Govt.	E_{91}	.	.	.	.	.
	10. Not Emp.	$E_{10,1}$	.	.	.	.	$m_{10,9}$

The final step is to combine the information in the Intersectoral Mobility Matrix with that in the Intersectoral Earnings Differential matrix. We shall refer to the resulting matrix as the Mobility Weighted Earnings Differential matrix (MED). The elements of the MED_{kj} matrix are formed by multiplying the corresponding elements of the M_{kj} matrix and the E_{kj} matrix. Because the M_{kj} sum to 1 for each column, the sum of the s^{th} column of the MED matrix shows the total gain (or loss) in earnings associated with one worker moving to sector s . An element of that column, MED_{rs} , shows the part of the total that is due to movement from sector r to s .

The MED matrix is essential to the calculation of replacement impacts. It provides an estimate of the net change in earnings associated with the filling of a job vacancy in any industrial sector. For example, if a Corps project has hired a worker from the mining sector, then the column of the MED matrix associated with mining will show the net employment impact associated with filling one job in the mining sector.

MOBILITY WEIGHTED EARNINGS DIFFERENTIAL MATRIX

	1. AG.	2. Mining	3. Constr.	. . .	9. Govt.
1. AG	$MED_{11}=M_{11} \cdot E_{11}$	$MED_{12}=M_{12} \cdot E_{12}$	.	. . .	$MED_{19}=M_{19} \cdot E_{19}$
2. Mining	$MED_{21}=M_{21} \cdot E_{21}$				
3. Constr.	.	.	.	. . .	.
.	.	.	.	. . .	.
.	.	.	.	$MED_{rs}=M_{rs} \cdot E_{rs}$	.
.	.	.	.	. . .	.
9. Govt.	$MED_{91}=M_{91} \cdot E_{91}$				
10. Not Emp.	$MED_{10,1}=M_{10,1} \cdot E_{10,1}$				

Three other concepts need to be introduced before the complete algorithm for calculation of replacement impacts can be described. First, the replacement lag (l) is a constant, denominated in weeks, which indicates the average length of time that a job remains unfilled after a resignation occurs. Second, a destination vector (D) has to be defined. It shows the absolute number of vacancies that are to be filled in each industrial sector. The round 1 destination vector (D_1) shows the vacancies created in each of the nine sectors by the Corps project. Finally, an index r must be defined to indicate the round for which replacement impacts are being calculated.

Round 1 (r=1) Replacement Impacts (RI_1)

In matrix notation:

$$RI_1 = \left(\frac{52-r \cdot l}{52} \right) \cdot MED_{kj} \cdot D_1$$

Writing out the elements of this equation, we have,

$$\begin{bmatrix} ri_1 \\ ri_2 \\ . \\ . \\ ri_9 \end{bmatrix}_{(10 \times 1)} = \left(\frac{52-r \cdot l}{52} \right)_{(1 \times 1)} \begin{bmatrix} MED_{11} & MED_{12} & . & . & . & MED_{19} \\ MED_{21} & MED_{22} & . & . & . & . \\ . & . & . & . & . & . \\ MED_{10,1} & . & . & . & . & MED_{10,9} \end{bmatrix}_{(10 \times 9)} \begin{bmatrix} d_1 \\ d_2 \\ . \\ . \\ d_9 \end{bmatrix}_{(9 \times 1)}$$

and total, round 1 replacement impacts equal the sum of the RI vector. The first term on the right of the equation adjusts for the amount of a year remaining after the replacement lag is accounted for. For example, if $l=4$ weeks and $r=1$, then the term equals $48/52$ or $12/13$, so the annual earnings differential is reduced by that factor. Multiplication of the MED matrix and the destination vector generates estimates of total earnings differentials. For example, d_1 eventually gets multiplied by each element of the first column of MED. Thus, if a total of seven jobs have to be filled in sector 1, the product of d_1 (7) times each element of the first column of MED will calculate the total increment in replacement impacts associated with this sector. The same thing happens with d_2 and the second column of the MED matrix and so on.

Round 2 ($r=2$) Replacement Impacts (RI_2)

In each new round, $r=r+1$ and as long as $52-r \cdot l$ is greater than 0, the algorithm continues.

$$RI_2 = \left(\frac{52-r \cdot l}{52} \right) \cdot MED_{kj} \cdot D_2$$

The only new issue here concerns calculation of the D_2 vector. But we know what sectors were filled in round 1, so we can use the Intersectoral Mobility Matrix to figure out the sectors which were vacated in round 1. In general,

$$D_r = M_{k-1,j} \cdot D_{r-1}$$

Specifically,

$$D_2 = M_{k-1,j} \cdot D_1$$

The only modification is that the last row of the $M_{k,j}$ matrix is eliminated because no job openings are created when a job is filled by a previously unemployed person. The multiplication of $M_{k-1,j}$ times D_1 provides an estimate of the total vacancies created in each of the nine sectors that have to be filled in round 2.

$$\begin{array}{c} D_2 \\ \left[\begin{array}{c} d_1 \\ d_2 \\ \cdot \\ \cdot \\ \cdot \\ d_9 \end{array} \right] \end{array} = \begin{array}{c} M_{k-1,j} \\ \left[\begin{array}{ccccccc} M_{11} & M_{12} & \cdot & \cdot & \cdot & M_{19} \\ M_{21} & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ M_{91} & \cdot & \cdot & \cdot & \cdot & M_{99} \end{array} \right] \end{array} \cdot \begin{array}{c} D_1 \\ \left[\begin{array}{c} d_1 \\ d_2 \\ \cdot \\ \cdot \\ \cdot \\ d_9 \end{array} \right] \end{array}$$

Round 3 (r=3) Replacement Impacts (RI₃)

$$RI_3 = \left(\frac{52-r-1}{52} \right) \cdot MED_{kj} \cdot D_3$$

Total replacement impacts equal the sum of the replacement impacts occurring in each round (RI₁ + RI₂ + RI₃ = . . .) until 52-r-1 is less than, or equal to, 0.

The next section discusses how empirical estimates were made of the variables necessary to estimate both direct and replacement employment impacts.

4.2 Data Requirements

4.2.1 Estimation of the Mobility and Earnings Differential Matrices

Several possibilities were considered for estimation of the mobility and earnings differential matrices. Ultimately, it was decided that the national Current Population Survey (CPS) sample was the most promising source of the required information. The 1982 tapes were used for the entire U.S. sample representing approximately 330,000 observations. The sample observations are then weighted to reflect state specific control totals. The CPS records a worker's status as of March 1982 in terms of industry and earnings and also reports the comparable data for one year previous. These data form the basis for computation of the mobility and earnings differential matrices.

Table 4-1 represents the Absolute Mobility Matrix while 4-2 is the Intersectoral Mobility Matrix obtained by dividing each element of the Absolute Mobility Matrix by its column sum. Each of the columns of the Intersectoral Mobility Matrix sums to one, therefore. The construction column of Table 4-2 shows, for example, that 88.9 percent of persons in the construction industry were in the same industry the year previous. However, 1.4 percent were in manufacturing, 2.2 percent were in trade, 1.9 percent in services and 3.8 percent not employed. There is no column showing movement to the unemployed, because this is not relevant for the impact calculations.

Table 4-3 presents the Intersectoral Earnings Differential Matrix estimated here in terms of differentials in annual earnings. We see that most of the entries are positive which implies that most people required a positive differential to switch industries. The exceptions are people moving to agriculture (column 1) and persons moving from mining (row 2). In the case of agriculture, non-financial factors may have dominated the move.

TABLE 4-1
ABSOLUTE MOBILITY MATRIX
(000's of persons)

From Sector: K=1,...,10	To Sector: j=1,...,9								
	Agr	Min	Cons	Man	TCPU	Trade	FIRE	Serv	Govt
Agr	1906	7	27	21	14	65	5	146	6
Mining	5	894	4	9	4	12	3	18	0
Cons	27	15	4627	97	43	123	12	102	15
Man	39	16	71	19273	52	300	35	284	19
TCPU	5	17	35	30	4933	59	18	80	19
Trade	43	24	113	345	83	15950	145	563	60
FIRE	2	4	20	57	18	94	4790	122	17
Serv	31	16	96	236	74	529	132	23159	69
Govt	5	6	12	36	13	29	13	111	3700
Not Emp.	80	18	195	463	86	810	103	929	86

Source: 1982 Current Population Survey and Mountain West Research - Southwest, Inc. 1983

TABLE 4-2
INTERSECTORAL MOBILITY MATRIX

From Sector: k=1,...,10	To Sector: j=1,...,9								
	Agr	Min	Cons	Man	TCPU	Trade	FIRE	Serv	Govt
Agr	0.888	0.007	0.005	0.001	0.003	0.004	0.001	0.006	0.002
Min	0.002	0.876	0.001	0.000	0.001	0.001	0.001	0.001	0.000
Cons	0.013	0.015	0.889	0.005	0.008	0.007	0.002	0.004	0.004
Man	0.018	0.016	0.014	0.937	0.010	0.017	0.007	0.011	0.005
TCPU	0.002	0.017	0.007	0.001	0.927	0.003	0.004	0.003	0.005
Trade	0.020	0.024	0.022	0.017	0.016	0.887	0.028	0.022	0.015
FIRE	0.001	0.004	0.004	0.003	0.003	0.005	0.911	0.005	0.004
Serv	0.015	0.016	0.019	0.012	0.014	0.029	0.025	0.908	0.017
Govt	0.003	0.006	0.002	0.002	0.002	0.002	0.003	0.004	0.926
Not Emp	<u>0.037</u>	<u>0.018</u>	<u>0.038</u>	<u>0.023</u>	<u>0.016</u>	<u>0.045</u>	<u>0.020</u>	<u>0.036</u>	<u>0.022</u>
SUM	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Source: 1982 Current Population Survey and Mountain West Research - Southwest, Inc. 1983.

TABLE 4-3
INTERSECTORAL ANNUAL EARNINGS DIFFERENTIAL MATRIX
(1981 Dollars)

From Sector: k=1,...,10	To Sector: j=1,...,9								
	Agr	Min	Cons	Man	TCPU	Trade	FIRE	Serv	Govt
Agr	3188	10062	9028	8743	9647	3495	1164	2033	10743
Min	-6233	-114	1115	1789	-628	1598	-23006	-717	-1912
Cons	553	10794	1595	6026	5562	3422	1398	1614	9801
Man	-1912	7215	1426	-270	3595	411	-697	-589	3803
TCPU	-16206	8887	4459	5727	457	854	-940	2882	5055
Trade	260	8262	5201	3872	6981	948	3022	2342	4213
FIRE	-2512	562	3923	3060	2292	1015	1079	-75	4486
Serv	1476	3645	3565	5277	6920	1866	4562	799	8104
Govt	29	8079	1174	5033	7732	1191	1474	375	183
Not Emp	4668	18882	12265	12162	15251	6447	11124	7638	11138

Source: 1982 Current Population Survey and Mountain West Research - Southwest, Inc. 1983.

In the case of mining, the data may reflect forced moves with corresponding earnings reductions as workers adjusted to generally depressed market conditions in mining in 1982. As would be expected, the largest positive differentials are associated with moving from the not employed category to any of the other industrial groups (row 10). As explained below in section 4.2.4, the earnings are adjusted to a common 1981 dollar basis.

Finally, Table 4-4 presents the Mobility Weighted Earnings Differential Matrix obtained by multiplying each element of Table 4-2 by the corresponding element of Table 4-3. The sum of each column of Table 4-4 shows the total gain in average annual earnings associated with one person moving into that industry. The construction column, for example, sums to \$2,175.67. This implies that one new job in construction increases average annual earnings by \$2,175.67. Nearly \$1,418 comes from higher utilization of persons already in the construction while \$461 comes from utilization of the previously unemployed. Smaller amounts are associated with the other industrial sectors. The total of nearly \$2,200 implies that new jobs in the construction imply significant gains in labor utilization and that this is a significant benefit of public works construction.

TABLE 4-4

MOBILITY WEIGHTED ANNUAL DIFFERENTIAL MATRIX
(1981 Dollars)

From Sector: k=1,...,10	To Sector: j=1,...,9			Man	TCPU	Trade	FIRE	Serv	Govt
	Agr	Min	Cons						
Agr	2830.72	71.53	48.11	9.29	25.84	12.73	1.24	11.68	17.73
Min	-15.43	-100.62	0.93	0.85	-0.51	1.10	-15.04	-0.53	-0.22
Cons	7.15	166.06	1417.96	28.46	45.14	23.57	3.35	6.49	38.16
Man	-34.75	118.30	19.50	-253.13	35.46	6.89	-4.70	-6.57	18.31
TCPU	-39.75	150.65	30.48	8.45	423.85	2.81	-3.38	9.10	24.72
Trade	5.29	199.68	113.27	64.96	108.82	841.19	83.38	51.76	63.60
FIRE	-2.60	2.41	15.25	8.61	7.77	5.32	982.55	-0.36	20.10
Serv	21.83	58.46	66.38	60.75	96.91	54.98	115.22	725.33	141.48
Govt	0.08	48.35	2.88	8.86	19.33	1.96	3.90	1.64	169.40
Not Emp	174.34	338.50	460.91	274.18	247.43	290.70	217.69	278.10	242.19

Source: 1982 Current Population Survey and Mountain West Research - Southwest, Inc. 1983.

4.2.2 Replacement Lag

A factor was developed to measure the length of time a job position remains vacant when a resignation occurs. The factor is instrumental in determining the number or rounds of replacement impacts that will be calculated as it represents the fraction of year remaining in which job vacancies can be filled. Once the cumulative replacement periods sum to 52 weeks, replacement impacts cease.

A replacement lag factor was determined based on telephone interviews with personnel managers of key businesses within each of the nine industrial sectors. The managers were asked to provide estimates of the length of time management requires to decide to fill a recently vacated position, and the length of time necessary to find a suitable replacement employee. The replacement lag is measured as:

$$(T_m + R_e) - N_e = RL$$

where:

T_m = length of time for management to decide a replacement is warranted;

R_e = length of time to find a suitable employee;

N_e = length of notice provided by the employee choosing to terminate his/her employment;

RL = replacement lag.

For example, if an employee gave two weeks notice and if it took management one week to decide to fill the position and three weeks to fill it, the replacement lag would be two weeks. The replacement lag periods by sector are summarized in Table 4-5. It should be noted the replacement lag factors reflect industry-wide norms independent of occupation. With the exception of government, the replacement period for all sectors averaged two weeks.

TABLE 4-5
REPLACEMENT LAG FACTORS

Sector	Estimated Lag
Agricultural	No Lag
Mining	2 weeks
Manufacturing	2 weeks
Construction	1 week
Trade	1 week
Fire	2 weeks
TCPU	3 weeks
Services	1 week
Government	18 weeks

Source: Mountain West Research - Southwest, Inc., 1983.

4.2.3 Survey Data

Key pieces of primary information were necessary to measure direct employment impacts and to define the round 1 destination vector used in the replacement impact computation. To derive the necessary information, a survey questionnaire was designed. The survey instrument is explained in greater detail in Section 3.1.1. Addressed here are the specific pieces of information gathered from the survey used to calculate direct and replacement employment impacts.

Information from the survey which was used for computation of direct employment impacts includes:

- month and year of current or first year employment on the Corps project;
- number of weeks not working in current or first year's employment on the Corps project and in the year prior to Corps employment; and
- usual weekly take home pay in current or first year's employment on the Corps project and in the year prior to project employment.

The industrial sector of employment the year prior to employment on the Corps project was used for the computation of replacement employment impacts.

The data on weeks worked were percentagized for both the current or first year's employment (year t) and the previous year's employment (year t-1). The data are shown in Table 4-6.

TABLE 4-6
PERCENTAGE OF WEEKS WORKED
LAKEVIEW LAKE, TEXAS AND L & D 26 ST. LOUIS, MISSOURI

Percentage of Weeks Worked	Texas	Missouri
Current or First Year's Employment:		
Mean	89.9%	92.1%
Median	99.9	100.0
Mode	100.0	100.0
Minimum	33.0	11.1
Maximum	100.0	100.0
Previous Year's Employment:		
Mean	87.3	76.6
Median	99.2	84.9
Mode	100.0	100.0
Minimum*	0	0
Maximum	100.0	100.0

*Indicates respondent did not work in previous year.

Source: Mountain West Research - Southwest, Inc., 1983

Review of Table 4-6 shows that the mean percentage weeks worked at both case study locations was greater on the Corps project than in the respondent's previous job. The mean percentage of weeks worked was 89.9 percent and 92.1 percent on the Texas and L & D 26 projects, respectively. This can be compared with the percentage of weeks worked in the year prior to Corps project employment of 87.3 percent in Texas and 76.6 percent in Missouri. This implies a substantial opportunity for direct employment impacts, especially on the Missouri project.

Table 4-7 provides summary statistics on the Lakeview Lake, Texas and St. Louis, Missouri survey respondents' adjusted weekly earnings.¹ Review of the table shows that the mean weekly earnings of respondents at both case study locations were greater on the Corps job than in their previous job even after adjusting for wage inflation. Workers' mean wages at the St. Louis, Missouri site exceeded the Texas workers' wages by over \$100 per week in both time periods surveyed. The fact that the Missouri job is a union job and the majority of the workers have had a long history of union affiliation could explain a large portion of the weekly earnings differential between the two case study locations. The mean weekly earnings differential for the Texas respondents on the Corps job compared to their prior year weekly earnings is 8 dollars. This is in contrast to a 27 dollar difference between Corps project employment and previous employment for the St. Louis, Missouri survey respondents. The relative difference in weeks worked between t and t-1 in combination with the weekly earnings differentials in the two time periods form the direct employment impact. The large earnings and employment utilization gap registered by the St. Louis respondents accounts for the L & D project's relatively high direct employment impact amount.

4.2.4 Other Required Data

An additional data element vital for the computation of both direct and replacement employment impacts is a price index which puts earnings in a common dollar base. The Hourly Earnings Index (for production or nonsupervisory workers on private nonfarm payrolls) was utilized for this analysis. The monthly hourly earning index data were converted into 1981 dollars and summed to form quarterly averages. The respondents' prior year salaries (t-1) were adjusted using the index for the quarter within

¹ Section 4.2.4 provides a more detailed explanation of the index used for the wage adjustments.

TABLE 4-7**ADJUSTED EARNINGS*
LAKEVIEW LAKE, TEXAS AND L & D 26 ST. LOUIS, MISSOURI**

Adjusted Weekly Earnings	Texas	Missouri
Current or First Year's Employment:		
(Current year 1981 dollars)		
Mean	\$303	\$448
Median	302	434
Mode	323	431
Minimum	130	215
Maximum	700	977
Previous Year's Employment:		
(Current year 1981 dollars)		
Mean	\$295	421
Median	296	411
Mode	314	418
Minimum	0	0
Maximum	955	955

*Usual weekly earnings adjusted to current 1981 dollars.

Source: Mountain West Research - Southwest, Inc., 1983

which the midpoint of their 12 month period of prior employment fell. The current year's weekly earnings (t) were adjusted using the index for the quarter in which the midpoint of their employment tenure at the time of the survey fell. Table 4-8 illustrates the indices used to adjust the weekly earning estimates.

TABLE 4-8

**HOURLY EARNINGS QUARTERLY INDEX
(1981 CURRENT YEAR DOLLARS)***

(1981 Annual Average = 100) Year	Quarter			
	I	II	III	IV
1982	104.5	106.1	107.7	108.6
1981	97.1	99.1	101.0	102.8
1980	88.6	90.1	92.7	94.9
1979	81.7	83.1	84.8	86.6
1978	75.9	77.0	78.4	80.0

* Derived by dividing each quarterly index by the 1981 annual average index and multiplying by 100. Note the 1981 and 1982 indices were previously scaled at 1977 = 100 and 1980 through 1978 were previously scaled at 1967 = 100. The scales were first transformed to a 1977 = 100 base, then converted to 1981 current year dollars.

Source: "Employment and Earnings", 1978 through 1982; and Mountain West Research - Southwest, Inc., 1983.

4.3 Employment Impacts at Texas Case Study Site

4.3.1 Direct Impacts

Direct employment impacts will occur at the Lakeview Lake, Texas case study site due to the increase in average weekly earnings and the increase in weeks worked. Using the mean values of these variables as reported in Tables 4-6 and 4-7,

$$D = (WY_t \cdot WW_t - WY_{t-1} \cdot WW_{t-1}) \times 52$$

$$D = (303 \times .899 - 295 \times .873) \times 52 = \$773.$$

Thus, using average annual employment over the life of the Texas project estimated at 146 workers, total direct employment impacts are estimated at \$112,858 per year.

4.3.2 Replacement Impacts

Replacement impacts for the Texas site were calculated based on the algorithm described in Section 4.1 above. Average annual employment was assumed to be 146 and the round 1 destination vector was formed using the vector showing industry of previous employment derived in the survey and shown as Table 3-7. The distribution is shown in Table 4-9.

TABLE 4-9**PERCENT DISTRIBUTION OF PREVIOUS INDUSTRY
FOR CALCULATING ROUND 1 DESTINATION VECTOR**

Agr.	.01
Min.	.01
Cons.	.75
Man.	.02
TCPU	.04
Trade	.04
FIRE	.00
Ser.	.06
Govt.	.01
Not Emp.	.06

Source: Mountain West Research - Southwest, Inc., 1983

Further, the replacement lag was estimated to be two weeks. Based on these assumptions, average annual replacement impacts are \$2,147,784 in 1981 dollars.

If the replacement lag is specified to be four weeks, replacement impacts fall to \$1,278,869.

4.3.3 Total Employment Impacts

Total employment impacts amount to \$2.3 million per year at the Texas case study site or about \$15,500 per worker under the assumption of a two week replacement lag. Given a four week lag, total impact would be \$1.4 million or about \$9,500 per worker.

4.4 Employment Impacts at St. Louis Case Study Site

Direct employment impacts will occur at the St. Louis Study Site due to the increase in average weekly earnings and the increase in average weeks worked. Using the mean values of these variables as reported in Table 4-6 and 4-7,

$$D = (WY_t \cdot WW_t - WY_{t-1} \cdot WW_{t-1}) \times 52 \text{ and}$$

$$D = (448 \times .921 - 421 \times .766) \times 52 = \$4,686.$$

Thus, using average annual employment over the life of the St. Louis project estimated at 660 persons per year, total direct employment impacts are estimated at \$3,092, 760 per year in 1981 dollars.

It is worth noting the mean direct impact associated with this project is much larger than the mean direct impact of the Lakeview Lake, Texas project. This can be explained by two factors. First, the average difference in earnings between the workers' first year employment on the Corps project (t) and previous employment (t-1) at the St. Louis case study location was over three times that shown at the Lakeview Lake, Texas site. Second, the construction workers at the L & D 26 project were productively employed just 76.6 percent of the time in the year prior to starting on the Corps construction job compared to a 92.1 percent utilization while on the Corps job—a 15.5 percent differential, whereas workers surveyed at the Lakeview Lake, Texas project were working 87.3 percent of the year prior to starting on the Corps job compared to an 89.9 percent employment utilization while working on the Corps project—an employment utilization differential of just 2.6 percent.

4.2.1 Replacement Impacts

Replacement impacts at the St. Louis site case calculated in the same fashion as for the Texas site except that average annual employment is 660 per year and the percent distribution of industry of previous employment is shown in Table 4-10.

Given a two week replacement lag, average annual replacement impacts are \$10,834,390.

If the replacement lag is assumed to be four weeks, total replacement impacts are reduced to \$6,529,768.

4.4.2 Total Employment Impacts

Total employment impacts amount to about \$13.9 million per year during the construction period at the St. Louis case study site or \$21,100 per worker under the assumption of the two week replacement lag. Given a four-week replacement lag, the total would be \$9.6 million or about \$14,600 per worker.

TABLE 4-10**PERCENT DISTRIBUTION OF PREVIOUS INDUSTRY
FOR CALCULATING ROUND 1 DESTINATION VECTOR**

Agr.	.000
Min.	.000
Cons.	.960
Man.	.005
TCPU	.005
Trade	.005
FIRE	.000
Ser.	.005
Govt.	.000
Not Emp.	.020

Source: Mountain West Research - Southwest, Inc., 1983

5.0 Procedural Implications for Anticipatory Studies

5.1 Direct Impact Estimation

The direct impact estimation procedure outlined in the two case study applications has the advantage of accounting for the large number of variables that can affect the utilization of a work force. The two key summary indicators are usual weekly earnings and average weeks worked in the year previous to Corps employment compared to the first year of Corps employment. The direct impact calculations at the two case study sites are summarized in Table 5-1.

TABLE 5-1
DIRECT IMPACT CALCULATIONS AT THE TWO CASE STUDY SITES

	TEXAS	ST. LOUIS
	usual weekly earnings x average weeks worked	usual weekly earnings x average weeks worked
Annual Earnings During First Year on Corps Project	$\$303 \times .899 \times 52 = \$14,165$	$\$488 \times .921 \times 52 = \$21,456$
Annual Earnings During Year Previous to Corps Project	$\$295 \times .873 \times 52 = \$13,392$	$\$421 \times .766 \times 52 = \$16,769$
Annual Direct Employment Impacts Per Worker	\$773	\$4,687

Source: Mountain West Research - Southwest, Inc.

The table makes clear the very significant differences in the base data used to calculate the direct employment impacts at the two case study sites. These differences may be exaggerated because St. Louis is a union job while Texas is not, but they indicate in any event that care will have to be used in estimating the key variables for other projects. The Texas site has a much lower level of weekly earnings, a much smaller differential between usual weekly earnings on the Corps Project compared to a year earlier, and a much smaller differential in average weeks worked on the Corps Project compared to a year earlier than does the St. Louis Project. The result is that the St. Louis site has direct impacts per worker that are six to seven times larger than the Texas site.

Based on the variability in the data from the two case study sites, there is no basis for estimating direct impacts that would be associated with future Corps projects. It appears that additional construction worker surveys would have to be carried out to determine previous year's usual weekly earnings and average weeks worked. Additional research is also necessary on usual weekly earnings and average weeks worked on Corps projects. This can best be derived using the procedures followed at the two case study sites and applying them to other Corps projects under construction.

5.2 Replacement Impact Estimation

Estimation of replacement impacts is computationally quite complicated, but it depends heavily on secondary data that do not change from project-to-project. Thus, given that the computational algorithms have already been programmed, and the key mobility and earnings matrices already calculated from CPS tapes, application of the procedure is quite straight-forward. The only project-specific information required by the algorithm is the round 1 destination vector—i.e., the vector showing the industrial sectors from which the Corps construction force was drawn. Table 5-2 compares these vectors for the Texas and St. Louis projects. Here, the significance of the union versus non-union job is even more apparent. The St. Louis site experienced relatively little switching of industrial sectors as most of the workforce had previously been employed in union construction. The round 1 destination vector for the Texas project, however, shows considerably more switching of industrial sectors. Clearly, some additional survey data are needed to provide a basis for estimating the round 1 destination vector.

In the absence of additional primary data, the construction column of the intersectoral mobility matrix represents a possible set of assumptions that can be made about the sectoral origin of a construction work force. This vector is shown as the third column in Table 5-2.

Once the round 1 destination vector, the number of workers and the replacement lag have been specified, replacement impacts are calculated using the matrices derived from the CPS tapes for as many rounds as implied by the length of the replacement lag. Table 5-3 shows that the impacts per worker have some sensitivity to the project-specific assumptions on the destination vector, but that these are minor compared to the differences due to the implications of the assumption on the length of the replacement lag.

TABLE 5-2

**INDUSTRIAL SECTORS FROM WHICH CORPS CONSTRUCTION FORCE WAS DRAWN
(i.e., ROUND 1 DESTINATION VECTOR)**

	Texas	St. Louis	CPS Sample For Construction Sector
Agriculture	.010	.000	.005
Mining	.010	.000	.001
Construction	.750	.960	.888
Manufacturing	.020	.005	.014
TCPU	.040	.005	.007
Trade	.040	.005	.022
Fire	.000	.000	.004
Service	.060	.005	.019
Government	.010	.000	.002
Not Employed	.060	.020	.038

Source: Mountain West Research - Southwest, Inc., 1983

TABLE 5-3

REPLACEMENT IMPACTS PER WORKER PER YEAR

<u>Replacement Lag</u>	<u>Texas</u>	<u>St. Louis</u>
2 weeks	\$14,711	\$16,416
4 weeks	\$8,759	\$9,894

5.3 Questions for Future Research

Replacement of workers. The present research assumes that each job vacated by a worker moving to a Corps job will be replaced if there is sufficient time to accomplish the replacement. Work by EDA has suggested that this may not be the case. In fact, there may be a significant number of workers who are not replaced, especially if labor market conditions are soft. Since this variable would exert a strong influence on the size of the replacement impact, more needs to be known about the determinants of replacement.

Replacement lag. The present research used very general information to develop a measure of the length of time necessary to fill vacated positions. Additional work, perhaps in connection with research on whether replacement will take place at all, could increase our understanding of the lag times in replacement and the way in which they vary by industry.

Project data. The two case studies showed high variability in the key variables on which estimates of direct and replacement impacts depend. It is reasonable to suspect that construction-type, union status, and labor market tightness will contribute to variability in the earnings and average weeks worked variables, both on the Corps projects and in employment prior to the Corps project. It is desirable, therefore, that a stratified sample of projects be surveyed with the objective of increasing our understanding of variability in these measures of labor utilization.

Utilization of the information in project planning and evaluation. Much of the formal evaluation of water projects has been carried out in the context of national costs and impacts. Local or regional impacts, especially as they relate to the utilization of local labor resources have not figured importantly in the evaluation process. It is

important, therefore, that research be continued on labor market impacts.

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