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I. Report Summary
October 1976

A.	1. Project Title and Contract Number	Feasibility Study for Health and Nutrition Benefits of New or Improved Water Supply, PIO/T # 931-17-560-73
	2. Principal Investigator	Karl K. Kindel, ISPC, Bureau of the Census, Washington, D.C. 20233
	3. Contract Period	July 1, 1975 to October 31, 1976
	4. Period Covered by Report	July 1, 1976 to October 31, 1976
	5. Total AID Funding to Date	$243,613
	6. Total Expenditures Through Previous Contract Year	$195,613
	7. Total Expenditure Current Year	$ 48,000
	8. Estimated Expenditures for Next Contract Year	

B. Narrative Summary of Accomplishments and Utilization

Major accomplishments of this feasibility project include creating a complete and unified theory integrating the effects of water quantity available on health. This theoretical basis is used to translate hypotheses about water quantity availability into measureable, quantitative terms. A preliminary questionnaire was designed using terms and concepts with precise definitions developed from the theory, to test the impact, and the magnitude of the impact of water quantity availability on the health of 1 to 5 year old children.

To test this questionnaire and the complex procedures necessary to collect the required data, a pretest was implemented in Brazil, where the water system interventions are to be made by the state water authority, COPASA. The questionnaire, training and field procedures, and editing and data processing specifications were tested.

A complete and unique analytical model for testing the research hypotheses was specifically designed for this research, as well as a special sampling design, to handle the complex interrelations explicit in the theoretical model. COPASA has been identified as the counterpart agency for this project.

II. Annual Research Report

A. General Background

In 1975, the World Health Organization reported that only 35 percent of the population in developing countries were adequately supplied with water by community standpipes or household connections. Furthermore, only 20 percent of this 'adequately supplied population' were in rural areas. Because of the acute need for improved water supplies in these rural areas, provision of an adequate water system has become a major goal of international agencies in recent years.

A number of researchers have recently theorized that for rural areas, increasing the quantity of water from reasonably safe sources of water may provide significant health benefits without expensive water treatment facilities. However, in-depth research in this area has been practically non-existant.

This feasibility study focused on three policy questions crucial to the determination of potential health benefits of new or improved water supply systems in rural areas.

First: Are there significant health benefits in providing greater quantities of water? This question was researched with respect to 1) water availability; 2) water consumption and 3) water use. Since water availability is categorized by levels of sophistication of water systems, and since policy decisions are made at the water system level, water availability was selected as the primary water quantity variable. Although this was the focal point of the research, water consumption and use were also studied, and proved to be especially important in answering the question: how can the magnitude of health benefits be measured at the different levels of water availability?

Second: What extraneous variables reflect the social, economic and demographic characteristics of study towns which could confound the effect of the water supply intervention? Included at the policy maker level are also questions about auxiliary programs or projects, which enhance expected health benefits, such as health education programs, sewage disposal projects, or immunization programs.

Third: What information is necessary to provide a basis for health-related cost benefit estimates? Such estimates would enable water projects to be compared to other projects competing for available funding.

B. Statement of Project Objectives

The purpose of the feasibility study was to develop a theoretical framework to test the various hypotheses developed from the policy questions and implications outlined above, and to design appropriate survey research tools and analytical techniques to answer these policy questions.

The first step in building the theoretical framework required incorporation of the limited information available on 'water quantity' concepts, with the literature germain to disease transmission via water. Precise definitions of concepts were formulated from this theoretical construct, and survey instruments were then designed to measure these concepts. These survey instruments now include: a household questionnaire, a program and accompanying materials for implementation of a field survey, a sample design, and a plan for analysis.

The end product of the feasibility study is a complete system (methodology, procedures, survey tools, definitions and theory) for measuring the impact of various levels of 'water quantity availability' on health, developed for worldwide application.

C. Continued Revelance of Objectives

The objectives of this research need no major modification in light of the completed Pretest Analysis. The scope of final analysis will, however, be expanded to include not only analysis at the household level but also at the area (neighborhood) and town level. This expansion will measure anticipated "spread" effects, since implementing a water system affects more than just health at the household level.

Furthermore, the U.N. sponsored "Habitat" conference and the upcoming U.N. water conference in March 1977 place continuing priority on studying means of providing rural areas with adequate water. Thus the impetus for this project continues at the international level.

D. Accomplishments to Date

1. Development of Theoretical Construct

The feasibility study began with an extensive review of the literature conserving the impact of water on health. From this literature search evolved the first major accomplishment of this project: a theoretical construct relating certain characteristics of water to health, and showing direct and indirect effects of both water-related and associated variables.

White, Bradley and White's Drawers of Water classifies infective diseases related to water into categories which were used as the basis for this theoretical design. White, Bradley and White state:

> All infections related to water supplies are included (in the classification)--that is, all those likely to change in incidence or severity as a result of changing water supplies. Primary division is into four categories: those where water acts as a passive vehicle for the infecting agent, or water-borne diseases in the narrowest sense; infections that decrease as a result of increasing the volume of available water, or water-washed diseases; those where a necessary part of the life cycle of the infecting agent takes place in an aquatic animal; and last, those infections spread by insects that breed in water or bite near it.

The authors state that diseases related to quality generally are most important in heavily populated areas, where their prevention necessitates a completely pure water supply because of the danger of spreading these diseases throughout the population served by the water supply system. The incidence of diseases related to water quantity, called "water-washed" diseases, can be reduced by providing a greater volume of water. White, Bradley and White also note that diarrheal diseases seem to decline when greater volumes of water are available, although specific etiologies of all these diseases are not known.

The theoretical basis for this research is founded upon the research of White, Bradley and White, and numerous other studies. The diagram shown in Figure I displays the theoretical basis of the study developed from the research. It concentrates on the quantitative impact of water on health in accordance with the objectives of the study. The diagram begins on the left with the type of water

system, and divides into three basic characteristics of water which affect disease. How each water characteristic affects disease is displayed next, followed by the actual type of disease affected. Outcome variables, morbidity and mortality are shown last.

The availability of water in Figure I, is shown impacting on the total amount used by the household. This impact is not, however, the only impact since there are other factors, as shown entering the schema line, which determine the actual need for water and the perceived need for water. Of the different uses of water in the household, some will affect water-washed diseases, while others will not. Amounts of water used for hand-washing and clothes washing will, therefore be included, while amounts used for drinking and other unrelated uses are excluded. These uses are further broken down into the amounts used by the target population (1 through 5 year old children) and all other household members.

Under the column "Diseases Affected" are included four categories of diseases which are related to the outcome variables. At the top are: 1) insect vector diseases, such as malaria,in which insects transmitting the disease breed or bite in or near open bodies of water; 2) water-borne or water-based diseases such as cholera,and water-based (only) diseases such as guinea worm (dracontiasis); 3) partially water-borne or water-based, and partially water-washed diseases which are related to both water quantity and quality, such as amebiasis (most water related diseases fall into this category); 4) water-washed diseases related to the quantity of water, such as bacillary dysentery.

BRAZIL WATER RESEARCH PROJECT

Theoretical Basis Relating Water Systems to Mortality and Morbidity Measures

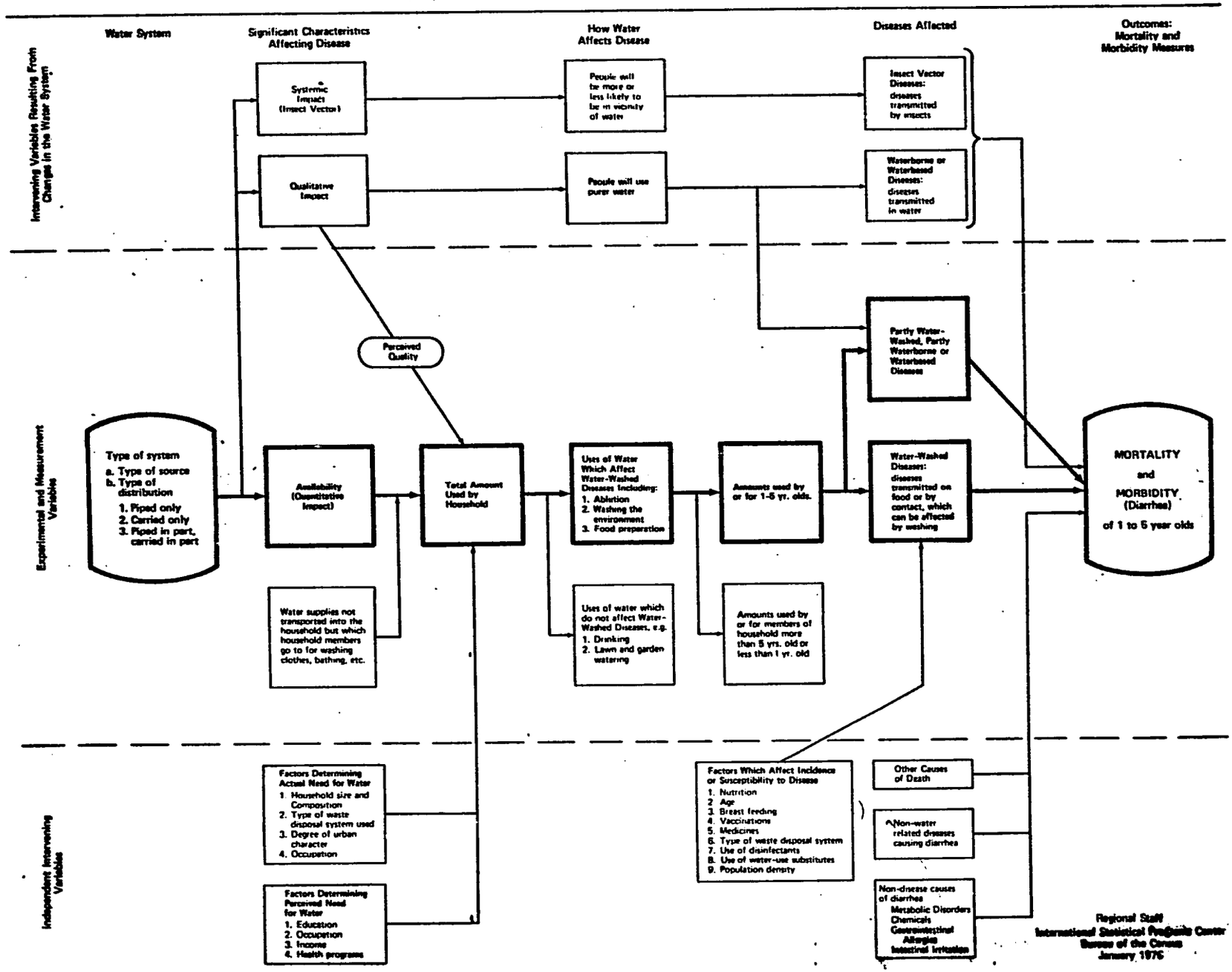

Figure 1

As diagrammed in Figure 1, there are various factors which affect suseptibility to disease as well as other factors which cause morbidity and mortality in terms of diarrhea.

2. The Measurement System: Development and Implementation in the Pretest

For each of the concepts necessary to the conceptual framework, at least one, and preferably multiple, acceptable measures were developed. For example, height and weight were proxies for nutrition. Morbidity was measured by the number of diarrheal episodes and diarrheal days over a period of time and by determining the number of bowel movements for the same period. Characteristics of sanitary facilities were grouped to form a scale for evaluation of existing facilities; other measures were developed to give indications of sanitary conditions and practices within the household.

The research instrument selected for gathering these measurements was a household questionnaire. In this pretest questionnaire were included subjective questions, measurements, and a section of observation items. For example, characteristics of the household sanitary facility were observed and recorded, distances between the facilities and the house and/or nearest handwashing place were measured, and water carrying containers were measured. The only measurement not included in the questionnaire was that of the bacteriological quality of the water used by the household. Water quality assessment was planned by a sanitary engineer and his recommendations are outlined in Appendix A.

Questions on the pretest questionnaire were required to both adequately measure the concepts and express concepts in a manner understandable to respondants. Design of the questions required close

cooperation between the U.S. technical advisors and the Brazilian staff to produce quality measures understood and acceptable to both experts in medicine, engineering, and survey research, and to the respondents. (The English translation of the pretest questionnaire is shown in Appendix B).

The feasibility field pretest checked the viability of some sampling and quality control procedures, as well as the questionnaire and auxilliary measuring equipment (scales, height measures, and water quality apparatus). The pretest required training for interviewers, supervisors and staff in practically all aspects of survey methodology, to determine whether people without prior medical, engineering or survey experience could operate the apparatus and conduct the household interviews satisfactorily. Programmed and classroom instruction with accompanying reference materials were prepared to teach the necessary operations. These training programs consisted of 1) two days of programmed instruction on sampling and interview techniques, 2) seven days of verbatim classroom instruction on each item of the questionnaire with mock interviews and practice field interviews, as well as 3) guided on-the-job observation, reinterview, and edit. A separate training was conducted at a later time for persons involved in the water quality data collection.

The Pretest was conducted in nine "Sedes" (roughly equivalent to county seats) geographically grouped into three groups of three "Sedes" each. Each "Sede" was within three hours by car of Belo Horizonte (capital city of Minas Gerais, Brazil) and within a maximum of one and a half hours to any other town within their group.

In selected segments, interviewers listed 1155 housing units; of those listed units, 318 were found to contain children aged 1 through 5 years. From these units, interviewers gathered information on 485 young children. Of the remaining listed housing units, only 9 units were refusals (less than one percent). (Refer to Appendix C Table 1).

From feedback provided by observation, reinterview, edit, and a two-day oral and written de-briefing session for all the interviewers and field supervisors, it is apparent that COPASA, with technical aid from the U.S. Bureau of the Census, is capable of fielding a survey. The organization developed by COPASA to implement the feasibility field survey methodology was thorough and professional.

Most of the needed operational improvements can be supplied by refining the training program to include more practice field interviews before the survey period begins, to provide realistic examples and illustrations during training such as those reported during the pretest and to provide a detailed supervisor's manual to have the final translation of survey materials done in Minas Gerais.

As the project and questionnaire took forms questions arose concerning the cooperation of individuals and towns to such 'personal' items as observation of sanitary facilities, and measurement of income. However, insurmountable problems did not materialize. The mothers who responded seemed to have little embarassment or reluctance to share these details with the interviewers. It was also felt that the public relations contact initiated between COPASA and the mayors of the pretest

cities was very helpful in preparing the towns for survey.

The nine pretest Sedes fell into three well defined groups from the water supply perspective. Five of the towns had low ratios of housing units with piped-in water to total housing units. Three of the towns had high ratios at the time of the pretest as well as extending back in time for more than five years. The remaining town had recently increased the number of household water connections. However, this town also had schistosomiasis infestation in nearby bodies of water, and thus remains in a separate classification.

These groups had quite different reported one week rates of diarrhea. The low ratio group had diarrheal incidence rates of 23, 32, 28, 23, and 23 percent, with corresponding ratio standard deviations of 0.069, 0.067, 0.06, 0.044, 0.099. The high ratio groups had incidence rates of diarrhea of 10, 10, and 9 percent, with corresponding ratio standard deviations of 0.026, 0.025, and 0.04. Thus the low ratio towns showed significantly higher incidence rates of diarrhea than the high ratio towns, while the intervention town occupied an intermediate position, exactly as would have been predicted. (See Appendix C, Table 2).

3. Proposed Research Based on Feasibility Year Work

An analytical model is being designed which will answer questions involving statistical significance as well as measuring the magnitude of relationships found to be statistically significant. This model will also be flexible enough to permit separate analysis of variables to develop indicators for policy guidance and evaluation of other water projects.

Some comment is required on why a household survey is proposed. Although much research has been done in water-related diseases, practically all of it has been concerned with diseases that are primarily water quality related. The etiology of many pathogens which can be controlled by maintaining high purity in water, has been extensively studied in clinical and epidimiological studies. Diseases which appear to be primarily related to water quantity have not been thoroughly investigated. The prevailing thought is that many of these are viral diseases which are difficult to isolate.

Because of technical problems, these diseases cannot presently be studied clinically or epidemiologically. Thus, household survey techniques are proposed to study these diseases. Proxies for infectious morbidity (bowel movements, diarrhea episodes, fevers, anorexia) are used since no specific pathogens can be identified for most of the diseases wich are primarily water quantity related.

Many relationships other than the effects of water availability on health will also be investigated. (These are broadly shown in Figure 1). For example, such variables as environmental sanitation, hygienic practices, child care practices, nutrition, water use and sewerage disposal are studied in terms of how much each contributes to reductions in morbidity in conjunction with different levels of water availability. Education, literacy, health programs, housing conditions and characteristics, income, family size and medical care will also be analyzed in relation to water availability. Analysis of these variables may allow description of optimum conditions necessary to obtain the greatest health benefits for given levels of water supply. To accomplish this,

the concepts, definitions and final questions in the questionnaire are to be designed based on the analytical framework and anticipated results.

Four concepts were defined during the last half of the Feasibility Study Year for the theorectical model in order to provide a logical basis for analysis. These concepts are labeled Child Health, Water Supply, Sanitary Conditions and Practices, and Socioeconomic Profile. Infectious morbidity, long and short range nutritional status, immunity, medical treatment, dietary status, and mortality, were intergrated into the Child Health concept. The Water Supply concept was identified primarily at the housing unit level, but also has an impact at the area and town levels. This concept is defined by the various levels of accessibility of the water supply presently existing and/or to be installed.

Two other main concepts were defined. One, Sanitary Conditions and Practices, encompasses factors determining the pathogen dose to which the child is exposed. The other, Socioeconomic Profile, was designed to represent the influence of economic well-being, both individual and socialized, and awareness factors towards the use of resources in the promotion of child health.

Given this perspective, a sample design was achieved consisting of five components:

(1) Before sampling, cross-classify towns by broad-brush characterizations of water supply and water supply interventions, population size, and accessibility. At the town level, population size and accessibility within the State of Minas Gerais were together determined to be a strong enough indicator of infection cycles and exposure to exogeneous infec-

tious agents, to enable cross-classification of towns, before sampling, in order to analytically counteract their influence as intervening factors.

(2) Within each "cell" of cross-classified towns, select for survey 15 percent of the towns.

(3) Within each town selected, define areas operationally and select 10 of these for inclusion in the survey.

(4) Within each area selected, survey three randomly selected housing units with children, per month.

(5) Within each housing unit selected, survey all children aged one to five years, inclusive.

The necessity of following the same children over time in order to evaluate the impact of water supply interventions dictated a periodic return to housing units, and six-months was selected as the period in order to minimize survey-reactive effects while enabling the study of the average impact on growth cycles of different levels of infectious morbidity.

The pretest results shown previously indicate the power of the sample design is sufficient on a monthly basis to discriminate between the levels of infectious morbidity associated with water availabilities, but perhaps only sufficient on semi-annual basis for the estimation of other effects.

The final requirement of the feasibility study was to design a system of analysis and data output. The proposed plan includes both modeling techniques and data tabulations on three levels: town time-series; time series of cross-tabulations within town strata; and

adjusted time series. The data for these three tabulations will be organized according to the four major concepts as described above (Child Health, Water System, Sanitary Conditions, and Practices, and the Socioeconomic Profile).

The simplest data will be the town time-series. These data will be produced monthly and will profile towns by all the important factors included under the four concepts of the analytic model. These data will be tallies, frequency distributions, proportions, etc. depending on the variable. They can be used for description and comparison of both towns and areas within towns.

The time-series of cross-tabulated data will be produced on a semi-annual basis. These tables will show breakdowns of the variables cross-tabulated to give estimates of effects queried in the policy questions and hypotheses. The tabulations will be organized by the four major concepts. A second part of these tables will include sampling variances and covariances associated with the variables.

Since much of the data will be tabulated on a monthly basis, but published semi-annually, they will serve as a feedback mechanism to the subject-matter analyst and survey specialist and provide the basis for published information as well. Thus, the data will be used to answer the hypotheses, give indications for further tabulations for analysis, enable the analysts to identify subject-matter problems in questions and responses and provide the survey statistician with needed feedback in order to maintain quality control and data intergrity during the survey.

The third tabulation, the adjusted time-series, will provide unbiased estimates of the Child Health effects of water availabilities and interventions by statistically adjusting for the unbalanced influences of extraneous variables. Thus, the effects of level of water (water quantity variable) on child health will be estimated and an unbiased outcome by standardizing over other variables.

Given this set of proposed tabulations, table outlines and plans will be developed. These output plans are to be implemented according to the timing of reports, the three tabulations and the major concepts outlined above.

E. Dissemination and Utilization of Research Results

Since there are no 'research results' from this feasibility study in terms of hard data, there have been no publications produced. The results of the feasibility study were intended for use as input to a full-scale study, or for a decision against proceeding. In this case, a proposal has been prepared for the AID Research Advisory Committee for a full-scale project.

Circulation of information concerning this project has been basically through seminars, personal contact and drafts of the proposal. There has been extensive personal contact with subject-matter specialists and agencies in the development of this feasibility study. Appendix D is a list of some of the major people and organizations contacted during the first Feasibility Study Year.

The Companhia do Saneamento de Minas Gerais (COPASA) has been involved in the feasibility study since its inception. They will be the implementing agency for the field work involved and have made

available a staff during that time to provide continuous input to the project. COPASA will also be one of the major users of the data. They have made a policy decision to provide adequate water supplies to the rural populace of their State. This research will provide them with a precise evaluation of the program and will enable them to develop badly needed data for future planning and implementation. COPASA cooperated during the Feasibility Year by providing staff and services and has volunteered significant financial support of the proposed research. A letter of commitment from them will be part of the proposal to the Research Advisory Committee.

Brazilians will also play major parts in other areas. It is expected there will be Brazilian input for health (epidemiology, child health, etc.), analysis of the data, and the various other components of the research.

F. Statement of Expenditures and Obligations and Contractor Resources

The PASA agreement called for an original budget of $195,613 for the year July 1, 1975 through June 30, 1976. This was amended for $48,000 additional funding to December 31, 1976.

This constitutes the first part of the final report for this project and the close-out of the feasibility study. The last part shows some tabulations of data collected in the pretest.