THE DEMAND FOR WATER RESOURCES INFORMATION:
A CONCEPTUAL FRAMEWORK AND EMPIRICAL INVESTIGATION

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(ABSTRACT)

This study develops and presents a conceptual framework which builds upon and extends the economics of information literature. Combining observations which emerge from a review of literature concerning organizational decision processes, this framework considers the nature of the demand and value for water resource information by individuals who participate in the decision making process found within public water management organizations. Based upon this conceptual framework the paper reports the results of an empirical model relating decision participant use of the Water Resource Council's Second National Water Assessment and hypothetical expenditures on "national assessment type information" to personal and agency characteristics in two water basin management situations; instream versus offstream water use competition in the Missouri River basin, and low

freshwater inflows to Chesapeake Bay. In addition, results of a contingent ranking investigation designed to estimate marginal water information values are presented and the potential use of the contingent ranking method by agencies in water data collection discussed.

Results of the investigations indicate that previous use of specific water information products and the level of expenditures made on certain types of water information *are* influenced by personal and organizational characteristics. Consequently, there can exist no "correct" information system and thus no "correct" data collection plan in the absence of knowledge concerning information value. Moreover, results indicate that contingent ranking procedures involving items of information may be successfully conducted in a mail survey format and that the information value estimates derived through this technique can be employed to promote greater efficiency in water data investment.

ACKNOWLEDGEMENTS

As in any significant endeavor, the ultimate completion of a doctoral dissertation is hardly the result of the sole efforts of one person. Many individuals share in the efforts leading to its completion. All too often, the contributions made by others are taken for granted and go without recognition. On this page, I would therefore like to take the opportunity to identify those who have assisted me in the present effort and extend to them my sincere appreciation.

First I would mention the tremendous contributions made by Dr. Leonard Shabman. Leonard has served has my major professor and as committee chairman since my arrival at Virginia Tech. Leonard's direction and guidance from the early stages of the research were critical to its development. As the research progressed, his insightful suggestions without doubt increased the relevance of the final product. It has been a pleasure and an honor to have been associated with him.

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The trouble isn't what people don't know;
its what they know that isn't so.

Will Rogers

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Chapter I

INTRODUCTION

1.1 *FEDERAL WATER DATA COLLECTION*

As a result of legislation and construction which has taken place over the past 50 years, the United States Government is deeply involved in developing, managing, and regulating many water resource projects and water related programs. Much of the early Federal involvement in water management was brought about by a desire to bring economic development to the arid West by investment in reclamation activities and through flood control. Grounded in the philosophy of the early conservation movement most closely associated with Theodore Roosevelt, "management by construction" exclusively characterized the Federal response to water resource management through the mid 1960s. While many Federal water resource projects were turned over to state or local management following Federal construction, most of the large multi-purpose projects remain under continuing Federal management. However, with the emergence of widespread concern regarding environmental quality in the 1960s and 1970s, and as a result of changing public perceptions directed toward water resource development, the Federal role in water management has undergone significant change.

Reacting to publicly expressed demands for clean air and water, Congress during the 1970s promulgated numerous pieces of regulatory legislation such as the National Environmental Policy Act and the Clean Water Act, creating new agencies and new responsibilities for the Federal Government. Simultaneously, appropriations for new water project construction entered a period of decline which continues to the present. As a result, the primary emphasis of Federal water management shifted from water resources development based upon project construction to the regulation of water quality and the management of existing projects. Thus while the Federal role in water resource management has undergone significant change within the past two decades, it remains nonetheless substantial.

According to the Office of Water Data Coordination's *Fiscal Year (FY) 1985 Federal Plan for Water Data Acquisition*, Federal expenditures related to water during FY 1983 were estimated to exceed $6 billion. Expenditures by state and regional water management agencies during the same period were also considerable. As a result of their significant management responsibilities, the Federal government, and numerous nonfederal entities, demand water resources information. This demand is derived from the the need to make informed decisions in specific problem contexts. In turn, water resources information is produced through the collection and analysis of data; the empirical operationalizations of concepts which seem relevant given an interpretation of reality. Data analysis is a process of interpretation which may include statistical and/or economic analysis, categorization, political evaluation, or perhaps nothing more than graphical display. Accordingly, the cost of providing water resource information to decision makers includes not only expenditures for water data acquisition activities but also includes the related costs of analysis and interpretation in specific problem contexts. Currently, more than thirty different Federal agencies use water data to produce water resources information.

To meet the demand for water resource data which derives from the demand for information to guide decision making, a complex diffused network for the collection of various types of water data has emerged within the Federal government. Of the $6 billion spent in FY 1983 by the Federal government for general water related expenditures, $138 million, or approximately 2.3% was for water data acquisition activities (OWDC, 1985). Water data collection by public agencies may be justified for several reasons. Because of the enormity of the data collection task, given the large geographic size of the United States and its diverse water resources, it is likely that a private data collection firm or group of firms would find it quite difficult to muster the capital or find the expertise to coordinate such a large undertaking. Government, on the other hand, because of its large size and the resources it commands, may be able to capture sizeable economies of scale in the collection of water data. Moreover, because demand for water resource information is concentrated primarily within Federal management agencies, and to a lesser extent state agencies, little general demand exists for water data. As a result, the Federal government as a matter of necessity has traditionally supplied its own demand for water resource data. Most importantly though, regardless of who may collect it, water data exhibit many of the characteristics of that class of commodities known as public goods. While it may be possible to exclude nonpayers from the right to use water data, the use of such data by one party does not in any way diminish the ability of others to use the same data. Because water data is nonrival in use, the quantity which would be supplied by reliance upon spontaneous provision by the private market would be expected to be less than that which is socially desirable. In such cases, economists have generally held that public provision of such commodities may be justified.

While more than 30 different Federal agencies use water resources data to produce information for decision making in support of their respective missions, only two or three could be classified as nearly self-sufficient. Most obtain substantial amounts of water data from other Federal agencies. By far the largest provider of water resource data is the Water Resources Division of the U.S. Geological Survey (USGS). Its FY 1985 water-data budget request of $68 million accounted for 49% of the total water-data budget requests of all federal agencies, which equaled $139.4 million. The next largest water data collection agency, the Army Corps of Engineers, had a FY 1985 data budget request of $17.5 million. Having primary Federal responsibility for water data acquisition, the USGS collects basic data concerning surface water quantity and quality, ground water levels and quality, water use, and data produced through other investigations. This provides a general purpose data base primarily for use by Federal water management agencies, but also of use to state agencies and others. When a Federal agency desires more detailed or specific data, it normally collects such data through its own in-house programs or contracts with USGS.

Because of the extent of the data interdependence between the Federal water management agencies, the concerns of one agency often become generally shared concerns. An area of current concern for many of these agencies is the expectation of reduced future funding of data collection activities.

1.2 *THE PROBLEM OF DECLINING WATER DATA COLLECTION FUNDS*

Primarily as a result of mounting public concern over the adverse macroeconomic effects of continued large Federal budget deficits on the U.S. economy, decreases in allocations for many traditional Federal budget items have been made in recent years. Among these decreases are allocations for water data collection. An illustration of this is the funding for the USGS water-data networks program, which involves both State and Federal agencies. While total funding increased from 1973 to 1982 and decreased only in 1983, in real terms funding has decreased continually since 1977. Since 1979, funding for this program has declined by a real yearly average of approximately 5% (OWDC, 1985). Additionally, the Bureau of Land Management, the U.S. Forest Service, and the National Park Service all indicated in the *FY 1985 Federal Plan for Water Data Acquisition* that they anticipated decreasing funding for water data collection activities.

James Bonnen (1985) has recently warned of a similar trend in the public collection of agricultural data. Concurrent to declining real allocations for data collection, Bonnen also notes that the cost of data collection continues to increase. While he notes that it is generally true that greater availability and use of recent computer technology has resulted in decreasing unit costs of processing, storing, and disseminating data, he goes on to point out that data collection remains primarily a labor-intensive activity. Because of rapidly rising labor costs, the cost of data collection has more than offset cost savings in data processing and dissemination (p. 4). While new technologies such as automated measurement systems, satellite telemetry, and remote sensing are resulting in less labor intensive data collection, the costs of such alternatives are still fairly high and their adoption has not been swift.

Against the backdrop of increasing costs and declining budgets, the federal water resource management agencies have indicated that they anticipate increasing demands for water data in coming years which will parallel increases in demand experienced during the past 10 years. These increases are expected in response to "factors such as societal changes, population shifts, economic development, and new legislation (OWDC, p. v)". As a result, these agencies have identified the future potential for a "gap between the need for water data and the capability to collect the data (p. v)". Indeed, the effects of such a gap may already be underway. According to the Office of Water Data Coordination (1985), some data-collection stations have already been discontinued and less streamflow, ground-water, water-quality, and sediment data is being collected. Taking these factors into account, the Federal water data collection agencies are now actively seeking ways to mitigate the limiting effects of decreasing water data collection budgets. Because many agencies rely on water data collected by other agencies, a cutback in data collection by one agency could have serious, adverse consequences for others. As a result, agencies have begun to establish so-called "critical networks"; a process in which agencies identify priority data items collected by other agencies which are critical to the continued support of their mission responsibilities. Moreover, some agencies have undertaken studies of their current collection strategies in an effort to maintain current levels of data provision at less cost. An example of the latter is the recent Stream-Gauging Cost Effectiveness study of the U.S. Geological Survey (USGS, 1984).

While such measures may help to offset the effects of initial decreases in data collection budgets, allowing agencies involved in water data collection to maintain current collection programs, at some point it seems reasonable to expect that additional cost-saving measures in data collection will become scarce. At that time, if costs of collection continue to increase and/or allocations for collection continue to decline, substantive changes in water data collection programs will have to be made. Collection of some data items may have to be discontinued. If agencies involved in water data collection wish to minimize the adverse effects these actions may have upon their decision making capability, they must ultimately consider the value of different types of water information in their decision process and the role and costs of water data items in producing that information. Following such consideration, it should be possible to efficiently invest remaining data collection funds across data items with the objective of maximizing the value of the information producible from the data. In this way, water management agencies may be able to minimize erosion of the decision support function which their water information system provides for any given level of program funding.

As the previous paragraph indicates, in order to determine an efficient investment strategy in the face of declining budget allocations for data collection, information on the costs of various water data items, production relationships between data items and information items, and the value of various water information items must all be determined. Data costs may be known, or obtained through engineering studies and production relationships between data and information may be obtained through disciplinary consensus. But, because water information is not traded in traditional markets, water information values are not readily available. While this would appear to present a major impediment to agency efforts directed toward the efficient investment of data collection budgets, investigation of the economic theory of information may provide clues for the estimation of such values. Traditionally, information demand and value have been concepts addressed within the domain of the economics of information. Moreover, it might be suspected that the principles which the economics of information suggests may provide other insights into the demand for information helpful to public agencies involved in water data collection. Unfortunately, as will be discussed more fully in Chapter 2, the development of the economic theory of information has left it poorly suited to the analysis of the demand for information in the public organizational environment of modern water resource management.

Given the concerns which water data collection agencies are now expressing and the limited extent to which the economics of information has dealt with the demand for information by individuals operating in complex organizational settings, the general objectives of this study are twofold. First the study seeks to partially address the perceived problem of declining future budget allocations for public water resource data collection, by suggesting an empirical approach for estimating information item values. With such values, agencies might be able to more efficiently determine the content of their data systems. This is somewhat different from other research, primarily conducted in the area of hydrologic network design, which has traditionally investigated the accuracy, storage, retrieval, and collection technique aspects of data system design. Data system content is specifically considered due to the paucity of research directed to this aspect of design, and because regardless of how efficient the techniques for collection, storage, and retrieval, and regardless of the level of accuracy, if the "wrong" data have been collected in the first instance, resources devoted to the attainment of these goals will be wasted. Second, the study seeks to build upon the theory of the economics of information, in light of information concerning organizational decision processes, to better account for the demand for information within the environment of water resources management. While this study will not lead to precise prescriptions for the design of any particular water data system, the development of such a conceptual framework, together with empirical applications, may provide agencies involved in water data collection with a better understanding of the relationship between the data they choose to collect and the information which they value in their organizational decision process, as well as providing an improved basis for considering the data system design problem. These general objectives are accomplished through the completion of the specific study objectives presented in the following section.

1.3 *OBJECTIVES*

The specific objectives of this study are as follows.

1) Extend the economic theory of information to describe the demand for information by decision participants in complex organizational settings as a function of the training and responsibilities of the organizational decision maker and the scope of the decision problem he/she faces.

2) Specify and estimate empirical models to evaluate demand for water resources information by federal and state decision makers involved in river basin management in two case study areas. More specifically:

    a) Estimate empirical models based upon the conceptual framework of Objective 1 which specifies the relationship between characteristics of decision makers and the organizations in which they work, and the types of information they demand for water resources management in a river basin management context.

b) Demonstrate a contingent valuation analysis to estimate the monetary value of selected items of water resource information for river basin management decision making.

3) Assess the practicality and usefulness of the contingent ranking technique employed in Objective 2 for the design of public water data systems using an integer programming framework.

4) Develop recommendations for future research in the economics of information.

1.4 *PROCEDURES AND METHODS*

Work to accomplish Objective 1 which appears in Chapter 2 begins with a review of the data/information system model proposed by James Bonnen, followed by a review of the literature comprising the economics of information as well as the allied literature on hydrologic network design. As previously suggested, this review concludes that the economic theory of information fails to adequately deal with the nature of the demand for and value of information by individuals operating within a public organizational setting. Since it is this setting which characterizes modern water resource management, Chapter 2 continues with a review of the literature concerning organizational decision making and the use of information in complex organizational settings. Based upon a synthesis of the above areas of thought a conceptual framework describing the demand for water resources information by decision makers is proposed, leading to hypotheses regarding the effects of personal and organizational characteristics upon information demand.

Chapter 3 reports the work undertaken in accomplishing Objective 2a. Based upon the conceptual framework developed in Chapter 2, two empirical models of water information "demand" are first stated. These include; 1) a model relating a water resource decision maker's probability of having used the Second National Water Assessment to his personal characteristics and the characteristics of the organization for which he works, and 2) a model relating a water resource decision maker's level of expenditures on "assessment information", as elicited through a contingent expenditure procedure, to the same personal and organizational characteristics. Following a discussion of the survey, data acquisition methods, and estimation techniques, results of models are reported for the problem contexts provided by two case studies; competition between instream and offstream water uses in the Missouri River Basin, and low freshwater inflow to Chesapeake Bay.

Chapter 4 contains the work undertaken in completion of Objective 2b. Chapter 4 begins with a general introduction concerning the practice of nonmarket valuation including the recent development of contingent ranking. Following this, the economic theory underlying contingent ranking, stochastic utility theory, and previous applications of the contingent ranking technique are discussed. Next, the empirical model used in the two case studies is presented followed by the estimation technique and results. In Chapter 5, Objective 4 is met through a demonstration of the potential for data system design employing an integer programming framework. Finally Chapter 6 fulfills Objective 4 by the presentation of conclusions regarding practicality and usefulness of the techniques employed in the study, and recommendations for future research in the economics of information.

Chapter II

DATA, INFORMATION, AND VALUE: A REVIEW AND CONCEPTUAL FRAMEWORK

2.1 *PURPOSE AND CONTENT*

The purpose of this chapter is to provide a conceptual framework describing the demand for information by individu-al's involved in organizational decision processes. To establish a definitional understanding of the basic concepts of data and information, the chapter begins with a presentation of the data/information system model proposed by James Bonnen (1975). Subsequent to that presentation, a review of the economics of information literature is offered, followed by conclusions regarding its capacity to model the demand for water resource information in public organizational settings. Next, a review of the relevant aspects of the literature dealing with organizational decision theory is presented. Following these reviews, a conceptual framework of information demand which derives from the union of these areas of thought is proposed and a general model for the analyses that follow is discussed.

2.2 *DATA AND INFORMATION: A SYSTEMS MODEL*

Any attempt to gain an understanding of the demand for information and ultimately to suggest principles relevant to the design of data systems must be preceded by an understanding of the relationship and distinction between data and information. This critical understanding is perhaps best provided in a seminal article written by James Bonnen in 1975. The following discussion draws heavily upon that article in which Bonnen discussed the structure of an agricultural information system and the implications of that structure for analysis of agricultural policy. Bonnen's analysis applies equally well to data/information systems designed for water resource management and policy.

Prompted by a desire to explain the perceived increasing failure of long collected data series on agriculture and rural life to adequately reflect the modern agricultural sector, Bonnen was led to question the link between data and information. This questioning resulted in a model describing the nature of data and its relationship to analysis and information.[1] The model is extremely important to providing an understanding the links between data and information. As many others in addition to Bonnen have pointed out (Dunn,

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[1] While Bonnen refers to this model as a "paradigm" of information systems (p. 753), this would seem to be a misuse of the word paradigm.

1974; Eisgruber, 1978; Schefter and Moody, 1981), information and data are not equivalent, even though the two terms tend to be used interchangeable in everyday conversation. Information is produced only after the interpretation and analysis of data, given some relevant institutional context and analytical-conceptual framework.

In Bonnen's model, an *information system* is seen to be composed of two primary constituents. Figure 2.1 presents a graphic representation of the data-information relationship. The production of data (left half of figure), coupled with a system of analysis and interpretation (right half of figure), yields an informational output. Consequently, any information system has two essential components: (a) a data system, and (b) an inquiry system of conceptual models related to the decision system they are to support.

According to Bonnen, "Data are the result of measurement or counting", and are ". . . an attempt to represent reality by describing empirical phenomena in some system of categories (p. 757)". In the water resources arena, these categories may be expressed in various ways depending upon the issue under consideration. One familiar example comes from the way offstream water use is recorded. Typically, such uses are categorized as either municipal, self-supplied industrial, steam-electric, or agricultural. But, whatever

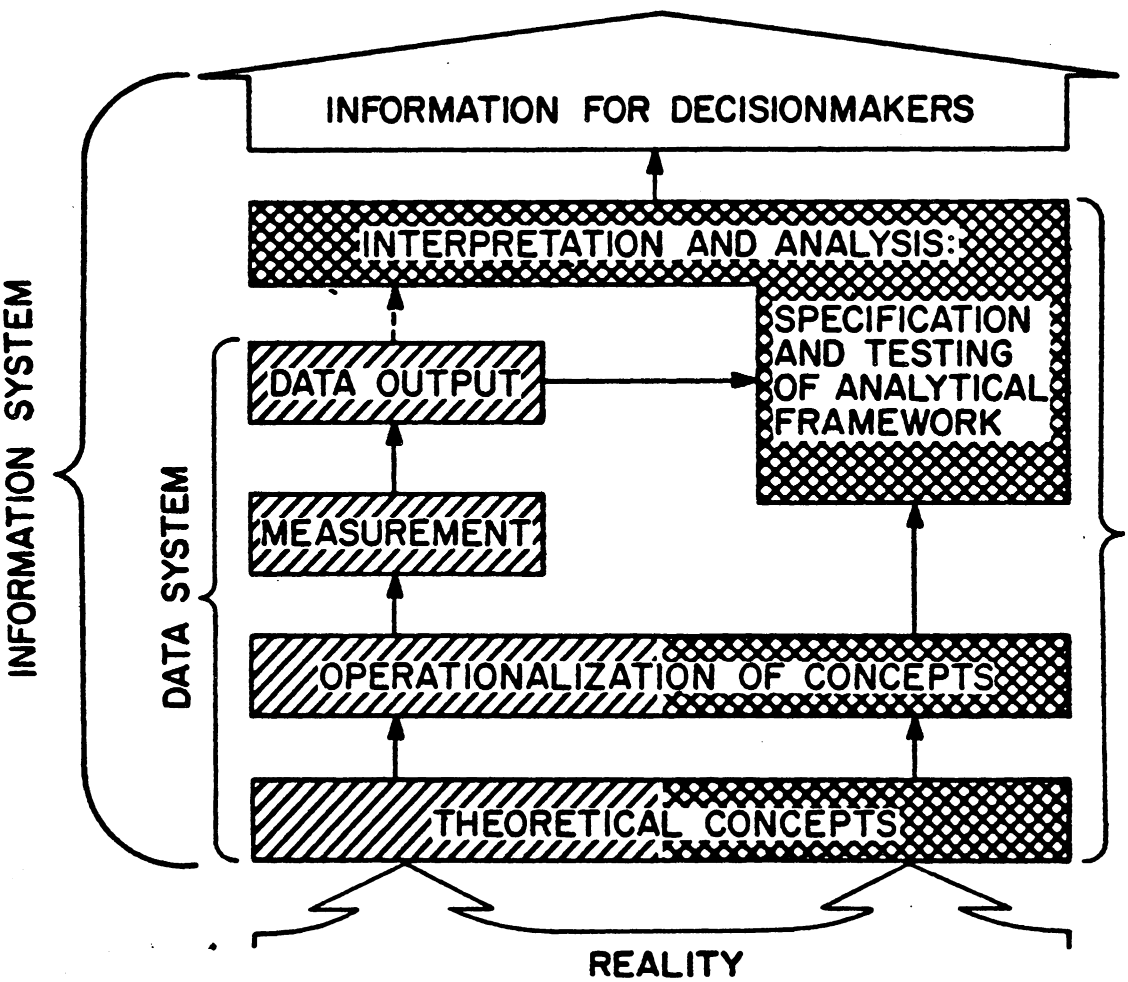

Figure 2.1: An Information System

the phenomena considered, the categories through which data are collected reflect an attempt to make operational certain concepts which purport to describe reality.

The second major constituent of an information system, the inquiry system, is the process through which the data are analyzed. It imposes form on the data and gives them meaning. As Figure 2.1 illustrates, far from being separate and distinct, the data system and the inquiry system are closely related. Each is based upon that same set of concepts which attempt to adequately describe "reality" at some point in time. While these concepts may not be explicitly expressed, they nevertheless will be implicitly held whenever the decision to collect data is made.

Since the basic analytical concepts, by their very nature, cannot normally be measured directly, satisfactory operationalizations of those concepts must be established. As an example, the analyst might wish to measure the monetary value of groundwater in alternative uses. If perfect groundwater markets existed, the ultimate operationalization of monetary value would be found in observed market price. But in the absence of perfect markets, some proxy for price must instead be used. An often used proxy is the cost of pumping and may serve as a satisfactory operationalization.

But as the graphic representation indicates, for the information system to yield internally valid information, both the concepts and the operationalization of the concepts underlying data and inquiry systems must be consistent. "An analytical hypothesis or model and the data for its empirical testing must have the same conceptual and definitional base" (Bonnen, p. 759). Should the concepts underlying the gathering of data diverge significantly from those relevant to the inquiry system, the production of information would be severely impaired.

While Bonnen's framework succeeds in clarifying the internal linkages of an information system, it does not make clear that the information system exists within a larger social context. Even if the data system and the inquiry system meet on the same conceptual plane, thus achieving internal consistency, it is quite possible that the information system may lack external validity. This may occur when basic phenomena change or when the agenda of relevant issues undergoes fairly rapid change,[2] without a corresponding change in the concepts underlying the information system. If the information system is incapable of addressing the

[2] An example of the latter, referred to in the previous Chapter, was the emergence of a new environmental quality consciousness during the late 1960s and early 1970s. As a result of that change, many agencies found it necessary to collect new types of data which they had previously never considered.

relevant concerns of decision makers, the existence of internal consistency is of little solace. Consequently, for an information system to serve as an effective decision support instrument, it must not only possess internal consistency, but must also possess external consistency.

With regard to the components of a data system, Bonnen states, "there are three distinct steps which must be taken before one can produce data which purport to represent any reality. These are conceptualization, operationalization of concept (definition of empirical variables), and measurement (p. 757)." A failure in any one of these three steps will limit the value of the data for information, and the prospects for overcoming the failure in any one stage by compensating with improvements in another are minimal. "Thus, the great improvements in statistical methodology and data processing techniques over the last generation cannot offset failures at the conceptual level, for no matter how one manipulates the numbers, one may still be measuring the wrong thing (p. 757)." According to Bonnen, one may be measuring the wrong thing given the concepts inherent in the existing inquiry system. However, it is also the case that one may be measuring the right thing in terms of the inquiry system, but the wrong thing with regard to relevant issues.

Perhaps the most important reason for emphasizing the distinction between data on the one hand and information, apart from the extent to which Bonnen's information system model more closely describes the reality of information production, is that decision makers demand information, not data *per se*. Recognition of this fact has important implications for the design of data systems and the way in which the design issue is approached. While this distinction is becoming more generally recognized, for most of the history of inquiry in the economics of information, data and information have been treated synonymously. Consequently in the following review of the economics of information literature it should be noted that references to "information" and "data" do not carry the special meanings of the Bonnen model. Later in the study, however, those definitions will again become important.

2.3 *THE ECONOMICS OF INFORMATION*

As an extension of economic theory, the economics of information has been an emerging and growing topic of interest within both economics and managerial science since the early 1960s. Generally stated, the economics of information analyzes the processes by which information is produced, stored, diffused and used. The importance of this area of research, and the interest which has been directed toward it by the economics discipline, exists for a number of reasons. First, the production, storage and diffusion of information, as economic activities, absorb a large share of both human and financial resources. In 1962 for example, Machlup estimated that the production of knowledge and its distribution might account for as much as 29 percent of the gross national product. Second, a large share of the production of information is in many cases financed by government. Third, information and the data used to produce it possess many of the characteristics of public goods. Finally, the nonexistence of organized competitive markets for many types of information creates difficulties of valuation and consequently questions regarding resource allocation.

Despite these compelling reasons for economic interest in information, for most of the history of economics, information was afforded little interest. As late as 1968, Stigler colorfully commented that information "occupies a slum dwelling in the town of economics (p. 171)". While considerable time has passed since this assessment, it must presently be concluded that while it may no longer reside in the slums, the economics of information has not yet reached economic's high rent district. This view is largely supported by Eisgruber's 1978 statement that "neither theory nor methodology exist to address adequately the economics of information and, until recently, little effort was made to overcome this deficiency. . . . no integrated operational theory exists for placing value on information or for selecting the most appropriate information system (1978, p. 902)." Schefter and Moody came to much the same conclusion in 1981 when they stated that "the economic theory of information is not well developed; it seems a nearly empty box. As a result it is difficult to estimate the benefits from and place a defensible value on a water use data base (1981, p. 985)".

Traditional economic analysis bypassed the problem of information production and acquisition. In most analyses, information was assumed to be uniformly available and costless. As a free good in unlimited supply, economic agents in competitive markets were assumed to have all relevant information concerning prices, exchange opportunities, production technologies, and the effects of consumption choices on utility. In small economies involving a limited number of economic agents, some of this information (prices and exchange opportunities) might conceivably be held by consumers and producers. However, because the competitive model required the existence of numerous atomistic consumers and producers such that no single party could exert significant control over the market, the assumption of uniformly available and costless information was seen to be quite unrealistic. The inevitable lack of complete information implied that individuals operated in an environment of uncertainty. With the emergence of research in the economics of information, an attempt was made to explicitly consider the role of information and the factors relevant to its acquisition for decision making.

The modern economic literature which falls under the category of information and uncertainty can be divided into two rather distinct branches (Hirshleifer and Riley, 1979). The first branch could best be described as dealing with the role of information in the operation of the economic system itself. This "market uncertainty" branch has concentrated on the analysis of such topics as consumer price search (Stigler, 1968), optimal product determination in situations involving price uncertainty (Jenner, 1966), job search and employee search (Rees, 1966), and monopoly with incomplete information (Maskin and Riley, 1979). The second major branch of the literature deals with what has been called "technological uncertainty" or more preferably "event uncertainty". Here the focus of the analysis is not about the terms of market exchange but concerns events exogenous to the market *per se*. This would include such information as that concerning resource endowments, effects of public policy decisions, and alternative outcomes.

In addition to these major branches, the literature on information and uncertainty may be classified according to the fundamental approach taken by the analysis. In the first of these approaches, characteristic of what has been called the "uncertainty" literature, the primary orientation of the analysis is to discover how individuals *adapt* to the lack of complete information (Sandmo, 1971). This approach is widely used in the risk and uncertainty literature. Alternatively, the second approach, which comprises what is normally referred to as the information literature, concerns itself with how individuals *overcome* uncertainty through the acquisition of information. A commonly used empirical technique employed in studies using this approach is Bayesian or statistical decision theory. Production of water resources information clearly represents an attempt to overcome uncertainty over natural resource endowment levels and consequences of management alternatives. Consequently those branches of the information and uncertainty literature dealing with market uncertainty and how people adapt to uncertainty are not particularly relevant to an understanding of the demand for water resource information, and are not presented here.

The idea which has more than any other typified the information literature is the view that information may be regarded as a marketable commodity. Viewed in this way, information may be analyzed using the economic principles of supply and demand (Arrow, 1962). "As it is exchange or potential of exchange or relevance to exchange that makes things commodities, one would think that economists would be interested in knowledge itself as a commodity. It is certainly something which is bought and sold (Boulding, 1966, p. 3)." Extending this idea, information has most often been viewed in the literature from a production standpoint. Thus, information is usually described as an intermediate good since it is the output of an inquiry process and an input to a decision process. The commodity argument could also be applied to data. Because data serve as inputs to the production of information, they could be described as primary inputs. However, in practice, the economics of information literature has seldom made a distinction between information and data. Both concepts have normally been reduced to the same general idea; a signal or experiment.

As a result of the economic commodity interpretation, in economics of information theory, "information is thus analyzed in the context of a traditional equilibrium theory where the chief tasks are to explain the quantities and prices which will mutually satisfy suppliers and demanders of information. Moreover, if the information market were perfect, the the quantities so produced could be regarded as 'optimal' (Newman, 1978)." By viewing information as as a commodity, the economics of information would suggest that to achieve an optimal level of information acquisition in the absence of an aggregate budget constraint, information would be collected until the benefits from the last unit just equaled the costs of obtaining it. Additionally, funds would be allocated across information types so that the marginal benefits of the various information types would be equated. Benefits in this sense would typically be related to the pivotal role information plays in the outcomes of decision making.[3]

Despite the appeal of regarding information as a marketable commodity, it was recognized from the beginning that information was in many respects a commodity with peculiar

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[3] While these efficiency arguments are typically discussed in terms of information quantity, they equally apply to the quality of information. For less important consequences of choice, for example, it is likely that less accurate and thus less costly information would suffice. Also, the purpose to which information will be put has important implications for how it should be collected. If information is to serve only a scanning or symbolic role, a statistical sample of the relevant populations might be adequate. If, on the other hand, information is to serve in a problem solving or investment decision, a complete census might be justified.

attributes. These attributes limit the extent to which the private good analogy may be applied to information. First, information exhibits some of the characteristics of that class of commodities which economists refer to as public goods. This observation, while not invalidating the commodity approach, does tend to complicate the analogy. The main characteristic which leads to the public or social nature of information is that it is nonrival in use. In other words, use by one individual or group does not preclude use by others. Consequently, the benefits of information production would not be expected to be appropriable by a producer without special legal protection since it could be reproduced at little or no cost and given away or resold. Further, once produced, transmission of information may be accomplished at low or zero marginal costs. This implies that information should be distributed at zero marginal costs to achieve optimal allocation. Accordingly, spontaneous provision through the competitive market would not be expected to result in optimal levels of resource allocation to information production.

Information is also distinct from more conventional commodities in that its quantity dimension is ill-defined.

> The Neoclassical framework requires information to be unambiguously measurable in quantitative terms, yet except in the narrowest possible view of information, it is simply not clear what such a measure might be. Furthermore, the central ques-

> tions concerning information are not those about its sheer quantity but its quality (or truth-value); and finding a measure for this dimension is just as difficult (Arrow, 1966, p. 24).

In trying to come to grips with the information quantity problem, the information theorist's (Raisbeck, 1963; Freeman, 1960) concept of a "bit" of information was tentatively suggested as one approach. Essentially, the bit represents that amount of information conveyed by one "yes or no" response. For example, if an individual wished to discover which one of 1024 numbered objects were contained in another individual's closed hand, he could do so with ten or less bits of information.[4] First, the individual holding the object would be asked if the object's number exceeded 512. Depending on the content of the response, the second question would narrow the remaining range by half. With each successive response the remaining range would be narrowed by 50 percent until, on the tenth question, only one number would remain. As Boulding pointed out however, the bit "abstracts completely from the content of either information or knowledge, and while it is enormously useful for telephone engineers who have no interest in what is being said over their telephones, for purposes of the social system

[4] In Bonnen's framework discussed previously, bits would represent not information, but data items. Their interpretation through the question-response exchange would ultimately result in the production of information; what was in the individual's hand.

theorist we need a measure which takes account of the significance and which would weight, for instance, the gossip of a teenager rather low and the communications over the hot line between Moscow and Washington rather high (1966, p. 3)." Consequently the use of the bit as a fundamental unit of information quantity was discarded since it is the value of the information message which is of importance as opposed to theories which would identify information with the cost or time of transmission (Lamberton, 1971). Because of the lack of an appropriate unit of measure for information, it has been described as an indivisible good (Stigler, 1968; Arrow, 1962), often characterized as a discrete "message" or an experiment.

2.3.1 *Statistical Decision Theory*

As indicated previously, the provision of information has most often been approached in the information literature as a problem of production. Information is thus demanded because it serves as an input to a decision production process specifically adding some new knowledge which the decision maker previously lacked. Consequently the determination of optimal resource allocation for information production in the economics of information is theoretically dependent upon the technological characteristics of the information production process and the nature of the market for information. The value of information is directly tied to the extent to which the information modifies the "probability distribution of random parameters of importance in economic decisions (Chavas and Pope, 1984, p. 709)". Attempts to estimate information values in the economics of information literature have in most instances relied upon some variation of Bayesian decision theory, so called because of its reliance upon Bayes formula, or more commonly called statistical decision theory.

In the statistical decision theory approach to valuation, information, consistent with the indivisible commodity nature of an information item, is defined as any message or experiment which may alter probabilistic perceptions of random events (Marschak, 1968). Distinctions between data and information, as made evident by the Bonnen model, are not normally recognized. Data and information are functionally considered to be equivalent. Typical uses of statistical decision theory deal with individuals in simple discrete choice situations in which a finite number of states of the world are likely. Such a situation is depicted in Figure 2.2 where an individual has available two distinct options, Action A_1 and Action A_2, and where two different states of the world, S_1 and S_2, exist with some probability of occurrence. The so-called payoff matrix indicates that if the individual chooses Action A_1 and it comes to pass that State S_1 occurs, the individual will receive benefits in the amount of $5,100. If, on the other hand, State S_2 occurs, the individual will benefit by the lesser amount of $4,900. Should the individual select Action A_2 and it comes to pass that State S_1 occurs, the individual will benefit in the amount of $4,500. Alternatively, if State S_2 occurs, $5,500 in benefits will be received. Based on previous information and subjective appraisals, the individual will form expectations regarding the relative likelihoods of the two states of the world. For this example assume that the individual expects the probability that State S_1 will occur is 60 percent, and thus the probability of State S_2 is 40 percent. A situation of total uncertainty on the individual's part would be characterized by the assignment of probabilities of 0.5 to each of the states.

Given uncertainty over which state will occur, the individual is assumed to consider the expected payoff from each of the actions he may take, and then choose the action which maximizes expected payoff. In this case, summing the products of payoffs and likelihoods for each action and then comparing the expected payoffs, it is clear that the individual should, based on his prior information and expecta-

PAYOFF MATRIX

STATE

ACTION		S_1	S_2
	A_1	$5,100	$4,900
	A_2	$4,500	$5,600

Figure 2.2: Decision Theory Example

tions, choose Action A_1 with an expected payoff of \$5,020. In comparison, Action A_2 would yield an expected payoff of only \$4,940. By establishing the individual's maximum expected payoff based on prior information, a baseline is established for determining the benefits of additional information. A common extension is to calculate the value of "perfect" information, which would inform the individual with 100 percent certainty concerning which state of nature would occur. Such information could be the product of an economic model, a consulting firm, or merely a friend of the decision maker. If, the decision maker were informed, for example, that State S_1 would occur with certainty, he would obviously select Action A_1 for a payoff of \$5,100. On the other hand, if informed with certainty that State S_2 would occur, the decision maker would select Action A_2 for a maximum payoff of \$5,600. Of course, when the individual contracts for the additional information he has no idea which of the two states of nature will be indicated. He purchases advice, not a particular signal. Therefore, to determine the maximum expected payoff with perfect information, the individual must weight the perfect information payoffs by his expectations concerning the likelihoods of the possible messages. The most logical weights to attach to the possible messages are the individual's prior probabilities. Consequently the product of $5,100 and 0.6 is added to the product of $5,600 and 0.4 for a total expected value of perfect information equaling $5,300. Subtracting the maximum expected payoff with prior information from the maximum expected payoff with perfect information yields a value of perfect information of $280 ($5,300 - $5,020). Because, in an expected value sense, the additional perfect information increases the individual's payoff by $280, this is the maximum amount he would be willing to pay for such information. If the cost of such information was in excess of $280, the decision maker would forego the purchase.

While calculation of the expected value of perfect information serves to illustrate the manner in which additional information generates benefits and thus value, in most cases information is not perfect. Take for example the less than perfect information source illustrated in Figure 2.3 In this example, the additional information again concerns which of two possible states of nature will occur. However, based on its previous record, it has been observed that when State S_1 actually occurs, the information source predicted that State S_1 would occur seven times out of ten and, in the remaining three instances, predicted that State S_2 was about to occur. When State S_2 actually occurs, the information source predicted correctly 80 percent of the time and incorrectly 20 percent of the time.

PROBABILITY SUCCESS MATRIX

STATE

PREDICT		S_1	S_2
	I_1	0.70	0.20
	I_2	0.30	0.80

Figure 2.3: Imperfect Information Source

Determination of the decision maker's willingness to pay for information from this less than perfect information source is accomplished through the use of Baye's formula. Mathematically, Baye's formula appears as:

$$P(A_i \| I_k) = P(A_i)\ P(I_k \| A_i)\ /\ P(I_k)$$

where:

$$P(I_k) = \sum_i P(A_i)\ P(I_k \| A_i)$$

and:

$P(A_i \| I_k)$ = the probability that State A_i occurs conditional to prediction I_k;

$P(A_i)$ = the probability that State A_i occurs;

$P(I_k \| A_i)$ = the probability of prediction I_k conditional upon the occurrence of State A_i;

$P(I_k)$ = the probability of prediction I_k.

Through the use of this probability formula, the decision maker can modify his prior probabilities in light of the new information, allowing recalculation of the expected payoffs from the alternative actions.[5] In the present example, recalculation indicates that if I_1 is observed, the poste-

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[5] While the statistical decision model has been suggested as an explicit description of the implicit benefit-cost calculus by which people make decisions, the appropriateness of the model has been questioned. For example, large anomalies have been observed in the ways in which people combine earlier and later information in making judgements. As a result, in actual decisions, behavior has been shown to be inconsistent with Bayesian models of information accumulation (Kahnemn and Tversky, 1973).

rior probability of State S_1 occurring is 0.84 while the probability of State S_2 occurring is 0.16. Similarly if I_2 is observed from the information source, the probability that State S_1 occurs is 0.36 while the probability of State S_2 occurring is 0.64. Using these posterior probabilities to calculate expected payoffs for each of the actions reveals that if I_1 is observed from the information source, Action A_1 should be pursued with an expected payoff of $5,068. If I_2 is observed, the decision maker should adopt Action A_2 for a maximum expected payoff of $5,204. Again, since the decision maker purchases an information service, rather than a specific signal, the expected payoffs resulting from the two predictions must be weighted according to the decision maker's expectation regarding the probability of receiving a particular signal. As in the case of perfect information, the decision maker's prior probabilities most logically serve this function. Multiplying the maximum expected payoff associated with I_1 by .60 and the corresponding payoff associated with I_2 by .40 and summing, the individual's maximum expected payoff with the less than perfect information source is revealed to equal $5,122.40. This amount, as would be suspected, is less than that with perfect information and greater than the expected payoff with no additional information. Subtracting the baseline expected payoff from the expected payoff associated with use of less than perfect information indicates the value of the less than perfect information is $102.40.

In general, based on the results of the examples involving perfect information and less than perfect information, it can be concluded that statistical decision theory implies that the greater the confidence which can be placed upon the information from a particular source, the greater the potential value of the information.

This observation suggests one last example of interest to the review of the economics of information. Suppose, for instance that the information source in the previous example was, based upon the record of its previous predictions, much less successful at predicting which state of nature would occur. In fact, regardless of which state of nature actually occurs, assume that the source is correct only 50 percent of the time. This situation would be equivalent to assigning 0.50 values to all the entries in Figure 2.3 . Employing the same procedures as in the previous example, it can be shown that the posterior probabilities which result from the use of Baye's formula equal the prior probabilities. In other words, information obtained from the information source fails to revise the decision maker's prior probabilities. Apparently, it tells him nothing more than he already knows. Accordingly, the maximum expected payoff associated with additional information is no different from that associated with no additional information. The only conclusion which statistical decision theory permits in this case is that additional information would not result in an increase in expected payoff nor would it alter the decision maker's choice of actions. In other words, from a statistical decision standpoint, the information is *without* value. Contrary to this conclusion, however it would seem conceivable that such information might be of personal value to the decision maker if for no other reason than it might corroborate his previous decision. Such an outcome is particularly possible if such information comes from a highly regarded acquaintance or another source which the individual admires or feels comfortable with. But because of the limited production orientation of statistical decision theory, and the economics of information in general, such consumption values for information are not normally recognized. This is a critical conclusion which will be further developed in section 2.4.

2.3.2 *Hydrologic Network Design*

In many respects the literature dealing with hydrologic network design is similar to that encountered in the economics of information. Moreover, it would not be inaccurate to conclude that they both subscribe to the same basic theoretical ideas. Consequently, hydrologic network design is considered here as a subset of the economics of information. Although originating primarily from within the hydrologic and engineering disciplines, hydrologic network design also acknowledges the desirability of an optimally designed information system based upon the equating of marginal benefits and costs. Unlike the economics of information however, most of the hydrologic network design literature has concluded that in practice the attainment of optimality in information systems is an impossible task owing to the difficulties posed by the characteristics of the information commodity. As a result, authors of this literature have focused their energies upon the attainment of admittedly sub-optimal goals such as maximizing statistical accuracy given some budget constraint, minimizing number of sampling points given some level of statistical accuracy, etc. The question of what information to collect has generally been avoided. Relatively more emphasis has been placed upon determining number and locations of sampling points once the decision of what to collect has been established. The determination of water information system content has most often been based upon developing a better understanding of all the components of the water cycle. Accordingly, within this literature some concern has been expressed over the relatively large amount of effort directed toward the design of precipitation networks versus the minimal amount of effort directed toward the measurement of soil moisture. The question of the value of soil moisture information relative to stream flow or precipitation information has not been addressed by the literature.

To this point, the hydrologic design literature has been directed primarily toward specific information use-collection decisions couched in a Bayesian decision theory framework. Accordingly, the majority of this work has been essentially normative, indicating how information collection decisions should be made as opposed to explaining how they actually are made. Thus, this approach is not essentially different from the approach which most authors have adopted in the economics of information literature. Analysis of large multi-purpose information systems, such as those commonly used by the water resource management community, has been intentionally avoided since the multiplicity of uses which such a system serves are not easily accommodated in a statistical decision theory framework. Not surprisingly, one principle emerging from the hydrologic network design literature is that information systems should, for the most part, be designed to serve single purposes. Multi-purposed national information systems are seen to serve primarily a contingency function, serving as insurance against unanticipated information demands.

According to Moss (1979), ". . .for hydrologic information to be of value, they must be used in at least one of the many aspects of water resources decision making (e.g. water development planning, project design, project operation, policy evaluation, or research). If the information are used only in an ancillary manner and do not actually affect the decision, they are superfluous and of no value." Thus, in hydrologic network design, as well as the economic theory of information, no possibility exists for information to have value other than that directly associated with the specific decision of interest.

2.4 *CONTRIBUTION OF THE ECONOMICS OF INFORMATION*

Do the concepts and approaches suggested by the economic theory of information, and the closely allied literature concerning hydrologic network design, provide an acceptable theoretical/empirical base for considering the design of public water information systems, particularly during a period of declining information collection budgets? Based upon the foregoing review, the answer to this question must be "not entirely". Clearly, the economic theory of information provides an essential beginning for understanding the issues involved in determining information system content with limited collection budgets. However, it will be argued here that the theory does not adequately accommodate many of the features which characterize information demand arising from the public organizational setting of modern water resource management. Since the demand for water resources information arises almost entirely from water resource decision participants located in such settings, this deficiency is considerable.

The theoretical arguments advanced by the economics of information literature would seem to far exceed the theory's empirical capability. Accordingly, while the economic theory of information might provide public water resource agencies with the technical decision rules for determining an optimal information system, it offers little with regard to how those agencies might make operational these concepts. The theory is limited not only by its failure to provide practical techniques to judge which information items should be added or omitted at the margin, but also by failing to suggest methods to determine if the existing system is even grossly sub-optimal. The development of statistical decision theory would appear to provide one approach to these issues. However, as Eisgruber has stated, "the major problem with the approach is that estimation of the likelihood (probabilities) of the various events is a difficult and gigantic task. As a result, this approach so far has been used primarily for relatively simple micro or firm problems (ex., value of frost forecasting information in preventing damage in orchards) (1978, p. 903)." Moreover, it is not clear that the approach is capable of being applied to situations other than those highly simplified cases characterized by the earlier examples. In terms of analyzing the design of multi-user multi-purpose information systems, the promise of the statistical decision theory approach would appear to be quite limited.

Perhaps the greatest deficiency of the economic theory of information for considering the design of water information systems is the limited production and supply orientation which practically all previous research has adopted. Hydrologic network design generally dismisses the problem of determining optimal information system content and concentrates instead on strategies for minimizing the costs of information collection and information storage. Accordingly, it is of little help in providing suggestions for determining water information system content in an era of increasing budget austerity. More importantly, though, the economics of information literature defines information to be an input to a decision production process; the demand for information is derived from each particular situation. Similar to any other factor of production, the value of information is directly tied to its physical impact on output (marginal product) and the value of the output. No provision is made for indirect benefits of information just as no provision is normally made for the psychic benefits of using organic fertilizer as opposed to inorganic fertilizer in farm planning models. As demonstrated in the statistical decision example and as stated in the hydrologic information system design literature, if additional information fails to revise prior probabilities then the value of the additional information, and the information from which it was produced, is by definition assumed to equal zero. This view ignores the possibility that there may be value in knowing that prior probabilities remain unchanged in the face of new information and that additional information may be of value in the larger decision process without being of direct value to the decision at hand. According to Scott,

> The *need* for information may be as much *psychological*, in view of the qualitative character of most administrative decisions, as it is technical in some quantitative sense. This then would suggest that the need for information is *satisficed* at

> points other than where the cost of information equals the value of uncertainty reduction. (1967, p. 225, original emphasis).

An additional problem with the production input definition of information, apart from the way in which information value is limited, is that very little is known or can be known about the decision production process. In the fairly simplistic micro-level situations where statistical decision theory has been applied, the link from information to some market commodity has been fairly direct (ex., advance weather information enabling the farmer to better schedule fertilizer applications resulting in greater output). Consequently, it has been possible to document the marginal product of information and the value of that marginal product based on market derived prices. In the demand for water resource information, the linkages are less direct. For example, it is seldom possible to determine the extent of the role a certain item of information played in the making of any given decision or policy. In addition, even if it were possible to determine its marginal product, there exists no obvious method to translate many water resource decisions or policies into monetary values. Thus, the value of the marginal product of an item of information is an elusive, and perhaps impossible, task.

To the extent that conventional economics of information fails to recognize the special characteristics of the demand for information in the complex organizational environment of water resource decision making, it would appear to offer little guidance to federal water information collection agencies in mitigating the potential effects of an austere budgetary environment; for helping them determine where to place their limited financial resources. The economics of information, primarily through its use of statistical decision theory, has been helpful in modeling the value of information acquisition in fairly simple micro-level situations as described above. In these situations, the value of information's marginal product is compared to its cost. The theory is less than adequate when applied to the problem of public investment in data and information.

But, the problem of government information policy is just as much a problem of decision making as is the problem of the behavior of private persons and firms. What would appear to be needed is a theory which, while building upon the foundations established by the economic theory of information, recognizes the organizational context of modern water resources management and the ways in which this context affects the demand for information. Schefter and

Moody have come to much the same conclusion in considering the demand for water use information.

> If we would hope to assess the value of water use information, we need to better understand the process by which policies and decisions evolve in the water resources arena and the role of water use information in this evolution. An increased understanding of this process might, at least, be helpful in the design of studies intended to produce water use information and, thus, in the design of a water use information base. (1981, p. 985)

Consequently, the following section presents a review of the main points of the literature dealing with organizational theory which describes the ways in which decisions evolve within the internal structure of complex organizations like the water resource management agencies. The results of such a review should be to suggest ways in which the economic theory of information could be adapted to better reflect those factors necessary to adequately consider the demand for water resources information.

2.5 *ORGANIZATIONAL THEORY*

Conventional impressions of decision making, whether by individual or by groups, envision the phenomenon as a highly rational and analytical process. The need to make a decision is brought about by the recognition of a problem within the decision maker's controllable environment. Before the process can proceed the exact nature of the problem must first be unambiguously identified. Following problem identification, the decision maker must clarify his goals and values so that they may be expressed in a consistent objective function. Next, he identifies all the alternative actions available to him and the costs and consequences of each alternative as they affect his goals. Finally, he selects the alternative which most closely matches his goals. If, as is often assumed, his goal is to maximize utility or profit, the alternative resulting in maximum utility or profit is chosen. This model depicts "man as a decision maker who is not only wholly rational in his behavior, but who is also supplied with a complete range or information and has the computational capacity to exploit this information in order to discover the best possible course of action (Castles, Murry and Potter, 1971, p. 16)." While this model of choice, either as a description of how individuals and groups make decisions or as a prescription of how they should choose, has clearly been of tremendous value in helping man think about decision making, it is at odds with observations made in actual decision situations (March, 1982). The most important factors which contribute to the divergence between conventional theories of decision making and the way it is actually undertaken are the computational limits of man and the limits on the amount and accuracy of information available to him. There exist very real limits to man's ability to simultaneously consider numerous alternatives, their costs and expected consequences, and to select the one alternative which maximizes a set of goals. In contrast to the rational-analytical model of choice, actual decision processes normally consider only a small subset of the possible alternatives. Additionally, since information on future consequences of current decisions can never be perfect, regardless of the amount of time or money invested in information collection and analysis, decisions may be made which in hindsight would appear to be suboptimal. One approach for attempting to overcome the computational limits of the individual has been the emergence of organizations; associations composed of numerous individual's engaged in specialized facets of the decision process. While such an arrangement is clearly capable of considering many more alternative actions than could one individual, there is of course an inescapable trade-off. As it increases in size, coordination of all the diverse elements of the organization becomes increasingly costly. Organization theory, which is of interest to a number of diverse disciplines (sociology, economics, management), seeks "to understand the everyday behavior of organizations as they make decisions (March and Olsen, 1976, p. 10).

Like the economics of information, organization theory means many different things to different people. As Cyert and March (1963) see it, there exist three major branches of organization theory. The first and earliest branch, which they identify as the "sociological branch", centers on the phenomena of bureaucracy and attempts to explain those factors which lead to the emergence of organizations. Second, the social-psychological branch stresses efficiency in organizations (e.g. productivity, speed), and has sought to examine experimentally the effect of exogenous changes in the organization's immediate environment upon efficiency. The third branch of organizational theory, which Cyert and March identify as "administrative", has focused on the executive in the organizational decision making process including the role of structure in promoting organizational goals. Unlike earlier theories of organization which influenced the development of the other branches, the administrative branch recognizes that members of organizations may have, and most likely do have, goals and preferences which differ from each other and which may diverge from the goals of the organization. Accordingly, this branch seeks "the development of theory explaining how decisions are made in organizations, with special emphasis upon the processes of executive influence and the impact of organizational position on individual goals and perceptions (Cyert and March, 1963, p. 18)". It is this last branch which is of most interest to the decision process which takes place within water resource management organizations and to the role that information plays in the organizational decisions.

Past work in organization theory has been for the most part qualitative. In general, it has focused upon a set of problems that are different from those considered within economics. Emphasis has been placed not on how output levels are set or how resources are allocated, but instead on the dynamics of how these and other decisions evolve within the organization. Accordingly, an investigation of the organization theory literature will not lead to precise rules for what types of information should be collected or how they should be collected, stored, or diffused. Instead, such an investigation should reveal that, for example, position within the organization will influence the individual's demand for information and how information may have value in addition to its ability to revise prior probabilities.

2.5.1 *The Organizational Environment*

While a standardized description is somewhat elusive due to the eclectic nature of the organizational theory literature and differences between authors, the following observations summarize the major characteristics of the organizational environment. According to Downs (1967), these observations are generalizable with few modifications to most organizations be they industrial, non-profit, governmental, etc. By definition, organizations are composed of many individuals. These individuals each have unique backgrounds, unique training, unique skills, and perhaps unique goals. They operate embedded within a larger organizational environment. The organization is said to also have goals. In the strict sense though, this is a statement of convenience since only individual's can possess goals. Organizational goals develop and are revised through the interaction of coalitions (groups of individuals responsible for the direction of the organization). After some period of time, the interaction of various coalitions within the organization results in a set of organizational goals. Accordingly, the decision on the final set of goals is to a large extent a political decision. Goals of the organization can be classified in to two general categories. Nonoperative goals are those which lack concrete measures of success or attainment. These goals tend to form a grouping of what might be called "high level" goals and normally are expressed as imperatives (ex., There should be more soil erosion control). Nonoperative goals, which are formed not only by the interaction of coalitions within the organization, but also by legislative intent in the case of public organizations, tend to define the mission of the organization. As such they place limits on what problems are acceptable for the attentions of the organization and, in turn, what alternatives are acceptable for solving problems. The second type of organizational goals are operative goals. These goals are characterized by the extent to which they have observable criteria for judging success. In contrast to nonoperative goals, operative goals typically express less global organizational objectives. March and Simon (1958) have suggested that operative goals play a larger role in governing organizational choice, on a day to day basis, than do nonoperative goals. March and Simon hypothesize that organizational decisions are made relative to the highest possible operative goal. In a sense, this hypothesis is not surprising since, as previously mentioned, the nonoperative goals tend to automatically condition the decision environment, specifying which problems and solutions are acceptable. Accordingly, decision processes take place within this preconditioned environment so that only consideration of operative goals remain necessary. For example, the U.S. Forest Service is by Congressional mandate required to provide for multiple uses (recreation, timber production, wildlife, etc) on the lands it manages. This goal forms part of the mission of the Forest Service and, like other nonoperative goals, lacks concrete measures of success or attainment. Limiting forest fire destruction, on the other hand, is an operative goal familiar to most forest districts. Success of programs designed to limit fire damage is evidenced by the number of acres of forest damaged in any given year. Since many fires are started by careless recreationists, one way to minimize yearly fire damage would be to ban all forest recreation. However, the nonoperative goal of providing for multiple uses would clearly rule out such solutions. Consequently, the nonoperative goal tends to constrain possible alternatives to those which maintain the multiple use concept. Within the set of acceptable alternatives, one will observe the decision regarding fire damage programs being made on the basis of other operative goals. Such goals might include minimizing costs or maximizing protection for certain unique natural areas.

As a result of changes in the environment from without and within the organization, organizational goals are constantly undergoing change and revision. Goals are also revised as a result of the experiences generated by previous decisions. While all goals, operative and nonoperative, are subject to revision, it is the operative goals which are the most prone to revision since the nonoperative high level goals tend to form the very core of the organization's existence. One outcome of the continuous revision of goals is that, at any given time, many organizational goals will likely be inconsistent. Such inconsistency is inevitable. It is not undesirable, and is not necessarily a signal of organizational irrationality. The organization exists, not primarily to maximize an objective function, but to maintain its ability to make decisions today, tomorrow, and the day after. Because of the different demands placed on the organization from without and from within, some amount of compromise in goals is absolutely necessary to preserve the decision making capability of the organization. One result of this compromise is that all goals are not simultaneously obtainable. Some goals, strictly interpreted, may be inconsistent with the fullest achievement of other goals. Accordingly, in any given decision, some trade-off between goals (weighting of objectives) is inevitable. Moreover, as the organization moves from one decision to the next, the weighting of objectives will tend to change.

A reoccurring theme in the organizational theory literature is goal conflict and the management of conflict. Because the organization is a collection of individuals and coalitions with differing goals and opinions, conflicts over goals, decision rules, and the decisions themselves are common. Conflict can occur between individual members of the organization, between coalitions, or between members of the organization and the organization itself. Resolution of these conflicts is achieved in a number of ways. In the first instance, authority pays a large role in conflict resolution. The importance of the paycheck, and the possibility of its loss, cannot be underestimated in mitigating conflict between organizational members and between members and the organization. Incentives are also powerful in managing conflicts of various types. Often, for example, side payments in the form of future policy commitments (log rolling) are used to reduce conflict between individuals or between coalitions concerning organizational goals or the nature of organizational decisions. Finally, appeals to organizational loyalty may result in reduced conflict between individual goals and the goals of the organization.[6]

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[6] To the extent that the organization is subdivided into divisions or branches on the basis of similar tasks (economic research branch) or on the basis of similar problems (estuarine protection group), appeals to organizational loyalty may be less effective since people normally identify most closely with their immediate environment. If the goals of the branch are at odds with the overall organization, the problem of conflict becomes more serious.

In organizational theory, the individuals who populate the organization are seen as specialized information processors. Based on the communication structure of the organization, the individual receives some informational input, processes that input, and based upon that processing initiates some action. The action forms the individual's output which may become the input to another individual higher in the organizational hierarchy. Individuals in the organization differ in at least four principle ways. First they differ in the actions they control. Secondly, they differ with respect to the information to which they have access. Thirdly, they are each different in the tasks they are expected to perform. In other words they have different responsibilities. And fourth, as previously mentioned, they have different individual goals. Each of these characteristics, in turn place limits on the individual's rationality; the extent to which the individual will select the best action from the set of all actions available to him in a given situation. The individual is limited by the extent of his skills, habits and reflexes. For example, an individual responsible for conducting econometric analyses, but who is not acquainted with certain of its techniques, is not likely to perform as well as an individual who is knowledgeable of those techniques. Individuals are also limited by their values (goals) and their concept of the purpose of the organization. When their goals do not correspond to those of the organization, it is unlikely that a rational choice of action from the organization's standpoint will be forthcoming. Finally, individuals in the organization are limited by their knowledge of those things relevant to the task they perform. This can be broken down into two components: (1) general decision making capabilities, and (2) information required to take an appropriate action in a specific situation. Information demands of the organization are thus dependent upon the needs of the individuals which comprise the organization. Further, the characteristics of the individual (goals, preferences), and the characteristics of the position he occupies within the organization (responsibilities) all shape his demand for information.

Clearly, information and the acquisition of information play a central role in the operations of the organization. However, the literature on organizational theory identifies two major types of information gathering activities. These are typically referred to as active search and monitoring. While monitoring occurs continuously, true active search occurs only intermittently. Active information gathering is stimulated when perceived performance lags behind organizational aspirations as set forth in the organization's goals.

This may be the result of decreasing performance on the part of the organization, or as a result of increasing aspirations based on past successes. Whatever the cause, the intensity of the search is directly proportional to the performance-aspiration gap. In early stages of active search, scanning of various decision alternatives is conducted to eliminate those alternatives which are obviously inappropriate. This may be the result of inappropriateness with the perceived agency mission, or infeasibility (costs exceeding the budget constraint). "Choice may also be limited by the reality that decisions proceed in a sequence where prior decisions eliminate future options (Shabman, 1986)." After this initial screening, a limited number of decision alternatives are selected for more intensive search. Typically, search will continue until, as a result of a decision, performance rises to meet aspirations or until aspirations adapt themselves to what is possible. The organizational decision theory literature suggests that decisions in complex organizations proceed in the face of "bounded rationality" (Simon, 1979). Choice will tend to be limited to incremental adjustments from the status quo; choice making is characterized by trial, error, and feedback as decision makers simultaneously define both acceptable problems to be solved and acceptable solutions. The organizational decision process searches for choices that will assure movement away from near-term problems, rather than toward long term goals (Lindbloom, 1979). In Simon's words decision makers "satisfice". To reduce the difficulty of dealing with a complicated, uncertain and threatening world, the organization uses routine, rules of thumb, and what may appear to be arbitrary rules in its search and decision process. Problem solving occurs only when a problem exists and is made conspicuous. Then the problem is solved by searching for a solution that works rather than an explicitly optimal solution. During periods in which performance meets or exceeds aspirations, a lower level of search identified as monitoring or surveillance is continually occurring. The monitoring occurs, not because there is dissatisfaction with performance, "but because past experience teaches that new developments are constantly occurring that might affect their (the organization's members) present level of satisfaction (Downs, 1971, p. 68)".

Unlike situations involving choice by private individuals, the decisions which evolve from active organizational search are not attributable to any one person. Decision making in the organization is the culmination of a complex series of actions and interactions between numerous decision participants. As a result, decisions appear to "happen" as opposed to being "made". Just as in the establishment of organizational goals, organizational decision making is the product of numerous compromises between coalitions. Perhaps the most conceptually accurate description of the nature or organizational decision making was made by Herbert Simon when he concluded that,

> Who really makes the decision? Such a question is meaningless - a complex decision is like a great river, drawing from its many tributaries the innumerable component premises of which it is constituted. Many individuals and organizational units contribute to every large decision . . .

2.5.2 *The Role of Information*

As indicated above, most literature comprising the area of organizational theory regards the individual in the organization as a processor of information. The regular communication channels of the organization supply the individual with information appropriate to his the tasks and responsibilities defined by his position. Based upon that information, the individual selects some action from the set of actions available to him. "Information is condensed and summarized as it goes through the organization and some information never reaches some points (Cyert and March, 1963, p. 110)." This scenario essentially comprises one step in the overall organizational decision process. In selecting their actions, every decision participant considers not only the issue before him and the effect of his action on that issue, but also the effect his action will have on the future pattern of the organization. In other words, decision participants are always asking, "How will what I do today affect my ability to participate tomorrow?". The uses the individual makes of information are seen to affect his ability to participate. As alluded to in the previous section, decision making in complex organizations should not be viewed as a series of discrete events, but rather as on ongoing dynamic socio-political process in which commitments to future policy support are made and in which reputations are enhanced or tarnished. Since the business of organization is to maintain decision making capability, reputation building is one way of doing this. There is almost a natural selection process which could be said to occur. Those decision participants who use important information intelligently enhance their reputations and play larger roles in future decisions. On the other hand, those who use important information poorly or those who use poor information, no matter how persuasively, will likely be discounted and will as a result play lesser roles in future decisions. Thus, information has symbolic value in addition to its "technical" value resulting from the revision of prior probabilities. If information only reinforces what was already believed to be true (technical value equaling zero), it may still be of value in an organizational decision process as a result of its symbolic value. Use of information for symbolic and reputation building purposes should not be considered as superfluous or as luxuries when considering the organizational decision process. They are an integral part of that process and it is entirely rational to expend resources in the pursuit of symbolism and reputation building if the result is that decision making capability is preserved over the longer run. Consequently, decision participants located within complex organizations would be expected to exhibit demands for various types of information. Clearly, if viewed in the most general sense, these demands would be expected to be influenced by the organization type, the mission of the organization, and the budget of the the individual's branch of the organization to the extent it limits the ability to obtain information. Moreover, because each individual is distinct in terms of values and goals, this demand would also be expected to be affected by the individual's background and training, his organizational responsibilities, and his experience level.

James G. March addressed this aspect of information demand in a 1982 article entitled "Theories of Choice and Decision Making". Because of the importance of the observations made in that article, the following extensive quotation is presented.

> In most discussions of the design of information systems in organizations, the value of information is ordinarily linked to managerial decision making in a simple way. The value of an information source depends on the decisions to be made, the precision and reliability of the information , and the availability of alternative sources. Although calculating the relevant expected costs and returns is rarely trivial, the framework suggests some very useful rules of thumb. Don't pay for information about something that cannot affect choices you are making. Don't pay for information if the same information will be freely available anyway before you have to make a decision for which it is relevant. Don't pay for information that confirms something you already know. In general we are led to an entirely plausible stress on the proposition that allocation of resources to information gathering or to information systems should depend on a clear idea of how potential information might affect decisions.
>
> A notable feature of the actual investments in information and information sources that we observe is that they appear to deviate considerably from these conventional canons of information management. Decision makers and organizations gather information and do not use it; ask for more, and ignore it; make decisions first and look for the relevant information afterwards. In fact organizations seem to gather a great deal of information that has little or no relevance to decisions. ...Were one to ask why organizations treat information in these ways, it would be possible to reply that they are poorly designed, badly managed, or ill-informed. To some extent, many certainly are. But the pervasiveness of the phenomenon suggests that perhaps it is not the decision makers who are inadequate, but our conceptions of information. There are several sensible reasons why decision makers deal with information the way they do.
>
> Decision makers operate in a surveillance mode more than they do in a problem-solving mode. In

contrast to a theory of information that assumes that information is gathered to resolve a choice among alternatives, decision makers scan their environments for surprises and solutions. ...Moreover, insofar as decision makers deal with problems, their procedures are different from those anticipated in standard decision theory. They characteristically do not "solve problems; they apply rules and copy solutions from others. Indeed they often do not recognize a "problem" until they have a "solution". ...

Information is a signal and symbol of competence in decision making. Gathering and presenting information symbolizes (and demonstrates) the ability and legitimacy of decision makers. A good decision maker is one who makes decisions in a proper way, who exhibits expertise and uses generally accepted information. The competition for reputations among decision makers stimulates the overproduction of information.

As a result of such considerations, information plays both a smaller and a larger role than is anticipated in decision theory-related theories of information. It is smaller in the sense that the information used in decision making is less reliable and more strategic than is conventionally assumed, and is treated as less important for decision making. It is larger in the sense that it contributes not only to the making of decisions but to the execution of other managerial tasks and to the broad symbolic activities of the individual and organization (1982, pp. 38-40).

2.6 *A DEMAND MODEL FOR WATER RESOURCE INFORMATION*

As presented, the literature dealing with the economics of information and the similar literature addressing hydrologic network design approach the demand for information from a limited economic production perspective. Information's demand results from its use as an input to a decision production process. Its value is limited entirely to the extent that it decreases uncertainty through the revision of prior probabilities. If, it fails to revise prior probabilities, the information is considered to be superfluous and of zero value. While knowledge of the nature of the decision production process is lacking, for expository purposes assume that the process can be summarized as $D=AI^{\alpha}M^{\beta}$ with $\alpha,\beta>0$ and $\alpha+\beta<1$. In this Cobb-Douglas type production function D represents the production of a decision while I represents the information input and M represents any other input to the process such as managerial time. α and β are assumed to be greater than zero since incremental additions of information or managerial time at the margin for any particular decision are expected to improve the decision. α and β are assumed to sum to something less than one since the decision production response resulting from proportional increases in both inputs is expected to exhibit declining returns. If P represents the direct benefits of the decision, and r_1 and r_2 represent the prices of information and managerial time respectively, the conditions which would maximize the benefits of the decision may be determined taking the partial derivatives of the payoff function and setting them equal to zero to obtain the first order conditions.

$$\text{Payoff} = P(AI^{\alpha}M^{\beta}) - r_1 I - r_2 M$$

First Order Conditions:

$$P\alpha A I^{\alpha-1} M^{\beta} - r_1 = 0$$
$$P\beta A I^{\alpha} M^{\beta-1} - r_2 = 0$$

Investigation of the first order conditions reveals the well known condition that the value of the marginal product for each of the inputs should equal its factor price. Solving the first order conditions for I and M allows determination of the derived demand functions for these inputs. In this case these demand functions are:

$$I = (\alpha/r_1)^{(1-\beta)/\gamma} (\beta/r_2)^{(\beta/\gamma)} (AP)^{(1/\gamma)}$$

$$M = (\alpha/r_1)^{(\alpha/\gamma)} (\beta/r_2)^{(1-\alpha)/\gamma} (AP)^{(1/\gamma)}$$

where $\gamma = 1-\alpha-\beta$.

Consequently, the demand for information, based upon a production orientation, is seen to be dependent only upon the price of information, the price of other inputs to the decision process, and the direct benefits of the decision.

As price of information increases, less is demanded. As direct benefits to the decision increase, the demand for information in turn increases. Information value is thus linked to decision outcomes.

For reasons discussed earlier, the limited production orientation to the demand for information may not serve as an adequate approach. While the value marginal product of information in the production of a decision may be zero in the statistical decision theory sense, such information may be of value to the decision participant and to the decision process in a broader sense. In the organizational environment, information has symbolic value in addition to the direct "technical" value normally attributed to it. Some information items may have more symbolic value than other items. As a result, in addition to technical production values, information may also exhibit consumption values. In addition to value attributable to *outcomes*, information exhibits organizational *process* value. If these values, are to be accommodated within a theory of information demand, it is clear that the theoretical approach to information demand must expand beyond a limited production perspective. One approach for accomplishing this is to adopt a consumer demand approach to information. By adopting such a perspective it is possible to account for the nontechnical values for information which are observed to exist within the decision process of complex organizational arrangements. Moreover, because the production relationship between information and decisions is not clear, limiting the extent to which information values could be estimated to aid information system design, adoption of a consumer commodity approach to information demand introduces the possibility of employing nonmarket valuation techniques which have been developed for estimating other consumer commodity values.

Approaching demand for information from a consumption standpoint allows the concept of information value to expand beyond that normally considered in limited production theories of information use. Transferring the concept of the spectrum of water quality benefits employed in Mitchell and Carson (1981), it is possible to identify at least three fundamental vectors through which information is of value in complex organizational environments. First, a distinction can be made between "use benefits" and what Mitchell and Carson refer to by label of "intrinsic benefits". The primary difference between these values is that "intrinsic benefits" are not necessarily associated with actual current use of the information. The potential for use is sufficient to generate benefits in this category. Use benefits are of two basic types: "direct use benefits" and "indirect use benefits". Direct use benefits correspond to what production theories normally view as the value of information; gains from the revision of prior probabilities. Indirect use benefits on the other hand, do not typically result from use of information in a pivotal technical sense, but arise because information is of use in the larger decision making process which occurs in organizations like the public water management agencies. These can be thought of as the benefits attributable to symbolism and reputation building which promote the decision making capability of the organization over time.

Intrinsic benefits in the Mitchell and Carson classification are also of two basic types: option benefits which are associated with potential use and existence benefits which are entirely divorced from use now or in the future. With regard to information, a good case can be made for the existence of option value. While information, particularly background monitoring of basic processes and phenomena, may be of little or no direct or indirect use value at present, such information may be of significant value at some point in the future. This is similar to what Schefter and Moody (1981) refer to as archival value with reference to water information. They go on to point out that "Any assessment of the value of water use information is further complicated by the fugitive nature of the information "resource". Water use measurements not made now are lost for all time; today's water use cannot be measured tomorrow. Consequently, there is an irreversibility associated with option value of the information produced from such information and a value associated with its production.

A very poor case, it would seem, could be made for information existence value. While it might be conceivable that some individuals could derive utility from the fact that water resource information was being produced, it seems more likely that such utilities would more likely be associated with the belief that water resources were being well-managed. To the extent that water resource information contributes to wise management it might have some amount of existence value but the link is only indirect.

Because of their participation in the water resource decision process, decision participants can be viewed as having individual demands for water resource information. Returning to the definition of information provided by the Bonnen information system model, this information is the product of interpretation and analysis of data within a specific theoretical and problem context. These demands, in turn generate derived demands for certain types of water resource data. Water resource information may help participants better understand the state of the world, understand consequences of management alternatives, or provide symbolic services for the participant in the decision process. Because individuals have different educational backgrounds, professional responsibilities, and different experience levels in water management, each will have his own particular informational demand priorities even when confronted with the same water resource problem.

According to the economic theory of consumer behavior, the demand for a good or service is dependent upon the price of the good or service in question, the prices of complements and substitutes, income, and the tastes and preferences of the consumer. While the first three determinants are fairly obvious, tastes and preferences are often represented in economic demand models by proxies summarizing the consumer's relevant characteristics. For example, other things being equal, one would expect that demand for encyclopedias would be greater in homes where the parents have higher levels of education. On the other hand, the family's religion would not be expected to influence demand for this commodity. For other commodities (ex. bibles), however, religion may play a highly significant role in determining demand. In this same way, the demand for water resource information exhibited by a water resource decision participant would be expected to be influenced by those individual characteristics which have some relevance to how he views water resource problems and responses to those problems. Accordingly such factors as disciplinary training/professional background and experience in water resource management should prove important in explaining the information choices he makes.

Based on the foregoing review of organizational theory, is clear that the organizational environment within which the water resource decision participant operates also places limits upon and influences his choices. Within a particular organization, for example, the responsibilities associated with a particular position will in part dictate what type of information the individual who fills that position will see as important. Viewing water resource decision participants across organizations, organizational type and organizational mission would be expected to exert influence over the information a particular individual would regard as important in a given situation. As the majority of water resource decision making occurs within public administrative agencies, a conceptual perspective on the uses of water resources information must include those salient factors related to the decision process in complex organizations. If the demand for water information is to be understood, in addition to recognizing the importance of the conventional determinants of demand, it is also important to recognize the relevant factors of the individual's organizational environment.

This is the conceptual framework which this study proposes. While most of the observations which result from organizational theory are difficult to operationalize in a model, an integration of conventional demand theory and organizational theory can be accomplished though the inclusion of the previously discussed organizational determinants into the information demand expression. Consequently, water resource information demand by organizational decision participants is seen to be dependent upon three sets of factors: characteristics of information, characteristics of the individual, and characteristics of the organization in which he works.

$$\text{Demand for Information Item} = f(X, Y, Z)$$

where:

X is a vector of characteristics describing the information item.
Y is a vector of characteristics describing the individual.
Z is a vector of characteristics describing the organization.

The most obvious characteristic of the information item which economic theory would indicate as being important is the price or cost of the item. One would expect that as the price or cost of an item of information increased given a limited organizational budget, the demand for that item of information would decrease, all other things being equal. In addition to price, other characteristics of information which would be expected to influence an individual's demand include the extent to which the information is aggregated, the content of the information (ex., hydrologic versus economic versus biological), and its temporal characteristics (ex., historical versus current conditions versus forecasts). Characteristics of the individual which would be expected to influence the demand for a given information item as previously discussed would include the individual's background as evidenced by his area of professional training and his experience or tenure in water resources management, and the nature of his professional responsibilities within the organization for which he works. Characteristics of the organization in which the individual operates would also be expected to influence his demand for any particular item of information. Among these characteristics are the mission of the organization (ex., developmental versus regulatory), the organizational type (ex., Federal versus State), and the annual budget of the immediate branch or division of the organization in which the individual is located.

Chapter III

EMPIRICAL APPLICATION OF THE CONCEPTUAL MODEL

3.1 *PURPOSE AND CONTENT*

The purpose of this chapter is to present the results of the first two of three empirical models characterizing the general nature of water resource information demand by water resource decision participants in two river basin management situations. Initially the primary informational focus of the models, the National Water Assessment, is presented and the reasons for its selection discussed. Next, the empirical models reflecting this commodity focus are presented including their specification and hypotheses regarding effects of personal and organizational characteristics upon "demand". These models include: 1) a qualitative response logit model relating use of the Second National Water Assessment to personal and organizational characteristics and; 2) an ordinary least squares (OLS) model relating expenditures made for "assessment information" to the same set of characteristics. Next, material supporting the river basin management survey focus is offered, after which the first basin study context, instream-offstream water use competition in the Missouri River basin, is discussed including survey procedures and questionnaire construction. Following this, estimation techniques and model results for the Missouri River basin context are presented and discussed.

Based upon the experience gained in the first basin study context, a second basin context, low freshwater inflow to Chesapeake Bay, is presented and resultant modifications to the empirical models discussed. Following that discussion, model results for the Chesapeake Bay Drainage basin context are presented.

3.2 *INTRODUCTION*

The general model of demand for a water information item by an organizational participant presented in the last chapter stems directly from the integration of conventional economic consumer theory and features relevant to organizational decision theory. It is, however, not particularly well-suited to empirical application designed to illuminate and test factors important to water information demand. Consequently, three different adaptations of the the general water information demand model are considered in this and subsequent chapters. Two of the applications are contained in the present chapter while the third is presented in the following chapter.

Typically demand models are used to explain changes in consumption as a function of marginal changes in commodity price as well as changes in other demand determinants. For the information commodity though, as previously established, no well defined quantity measure exists. An item of information is technically indivisible. Consequently it is difficult to represent the demand for a "lumpy" good within conventional demand expressions. For this reason it is not only more realistic, but also more practical, to view the demand for an information item in a manner analogous to a consumption durable. The individual's consumption decision is better treated as whether to acquire the information item rather than as what quantity is demanded (e.g., use of an information item or group of items, versus nonuse). In addition, like consumer durables, an item of information is capable of providing a stream of benefits across time. For these reasons, the first application of the general information demand model is couched as a use/nonuse qualitative choice model for a particular collection of information items. This model allows estimation of the changes that various personal and organizational characteristics have upon the probability of using the information collection under consideration. Because of the vast number of potential water resource information items and because of their individual specificity, analysis of information demand solely through use/nonuse models of behavior would necessarily have to consider the demand for numerous items of information in order to draw reliable conclusions concerning the impacts of various determinants upon water information demand. The practical difficulties of surveying and analysis imposed by having to consider the demand for such an array of information items were deemed considerable. For this reason, the second application of the general information demand model focuses upon water resource decision participant hypothetical expenditures on information items belonging to a a particular information commodity class. This analysis is similar to Engel function analysis except that, rather than investigating changes in expenditures on a commodity group as the result of changing income, the emphasis here is placed on investigating changes in expenditures as personal and organizational characteristics vary subject to a fixed level of income.

The third adaptation of the general information demand model which stresses organizational decision theory themes is the application of a nonmarket valuation technique to estimate decision participant willingness-to-pay, in terms of division or branch budget allocation, for specific water resource information items. This application and the potential for employing the willingness-to-pay estimates for improving the efficiency of information system design is assessed in the following two chapters.

While any number of water resource information items could have served for illuminating the water information choice model in the first two applications, this study concentrates on the National Water Assessment and a grouping of information items which will be referred to as "assessment information". Assessment information is a shorthand category of water information exhibiting certain general characteristics. These characteristics are common to the information which has traditionally be presented in the national water assessments. Information in this category is quantity oriented and is the direct result of measurement of components of the hydrologic cycle (e.g. streamflow, groundwater levels, withdrawals, consumptive use). In addition to being well known in the water resource management community, a National Water Assessment focus to the applications of this study may serve to shed light upon use of the Assessment and the value of "assessment information". Despite considerable discussions regarding this topic over the last few years, questions regarding the utility of the assessment process remain largely unresolved. In order to properly define that which is encompassed in the term "assessment information" and to explain why it was chosen for analysis, a brief digression into the history and content of the national water assessment process is necessary.

3.2.1 *National Water Assessment*

As a result of the perception of increasing water scarcity and the resulting expression of concern regarding its management, Congress passed the Water Resources Planning Act of 1965. In its statement of policy Congress declared,

> "In order to meet the rapidly expanding demands for water throughout the Nation, it is hereby declared to be the policy of Congress to encourage conservation, development, and utilization of water and related land resources of the United States on a comprehensive and coordinated basis . . ."

To accomplish these ends, the Act provided for the establishment of the Water Resources Council (WRC) which was charged, among other things, to "maintain a continuing study and prepare an assessment . . . of the adequacy of supplies of water necessary to meet the water requirements in each water resource region in the United States and the national interest therein, and to maintain a continuing study of the adequacy of administrative and statutory means for the coordination of water and related land resource policies and programs of the several Federal agencies . . .".

Clearly, from its statement of purpose, the Water Resources Planning Act, in establishing an ongoing national water assessment, sought an assessment process resulting in information to serve the needs of water policy development. While other uses exist, policy utility with regard to Federal water planning is the principle purpose of national water assessment. Since the establishment of the Act, two national assessments have been conducted by the WRC. The most recent, the second national assessment, was completed in 1978. While no such program is active at present, water resource assessments, as informational products of the water information system, have been expected to be the process by which emerging water resources management issues could be identified and alternative public actions discussed (WRPA, 1965, Sect. 102).

In their own way, each National Water Assessment was an attempt to provide one step in a continuing effort to determine the adequacy of the Nation's water resources to meet present and future water requirements as called for in the 1965 legislation. Consequently, the information contained in each assessment has been highly aggregated at the regional level. To accomplish their stated objectives, the assessments adopted a water balance framework wherein the primary goal was to account for the *quantity* of water as it moved in the hydrologic cycle. Little or no consideration was given to water quality. The information contained in the National Water Assessments has been further characterized by the extent to which man and his institutions were held external to the water cycle. Indeed man's only role, as recognized in the water balance approach, is as a net extractor of water from the hydrologic cycle. Further, water accounting items such as instream flow for wildlife maintenance were set at fixed levels with no consideration of the costs and benefits of reallocating this water for other uses.

Generally speaking, the majority of individuals involved in water resources management have been supportive of the concept of water assessment. However, once concluded, each assessment has been criticized in terms of its structure and detail. For the most part these criticisms have reflected differences in regional interests which are not easily reconciled, and the inherent difficulty in using nationally or regionally aggregated information for local problems. But more importantly, the assessments have been criticized for their lack of policy usefulness. James, Larson and Hoggan (1983), for example, in their review of the second national assessment suggest that because typical water resource assessments have been limited to an analytical approach (information, tools, and framework), they have provided information that was of very little use for water resource decision making. In part, this problem arises because the basic analytical question addressed, "Are a river basin's water supplies adequate to meet use levels based upon extrapolation of past trends?", does not serve the decision making process for water policy formulation. However, focusing on this question has permitted utilization of existing water use and supply information bases. Rephrasing the question to ask, "What factors underlie user conflicts over water resources?", would cause the perspective of the assessment process to expand beyond water budget analysis to consider the economic, legal, social and political, as well as physical aspects of water use and allocation. Ingram, in criticizing the physical resource focus of past assessments states, "It is . . . doubtful that an assessment that defines water problems in physical terms is helpful . . ." (p. 59). She offers specific suggestions for an improved water assessment process. First, water assessments must be cognizant of institutions. She states, "It is now widely recognized that institutional arrangements create 'water problems' which appear to be shortages of water but in reality are institutional problems" (p. 59). Second, water assessments should incorporate projections that are firmly grounded in economics. Ingram notes that "An appreciation of the economics aspects of water problems will show that 'needs' are really demands, and that use will change as the cost of water changes" (p. 60).

Clearly, the importance of past water assessments as primary sources of water information and the criticisms lodged at the product and process of water assessment suggest that investigation of the nature of the demand for "assessment information" could be a valuable contribution to the ongoing debate concerning its value and uses. Consequently, in the empirical applications to follow, attention will be focused upon those factors which influence use of the Assessment and those factors affecting the demand for "assessment information"; a shorthand for a set of informational characteristics common to the information which has traditionally been presented in the national water assessments. As alluded to previously, information falling into this category tends to be primarily quantity oriented and is directly associated with measuring components of the hydrologic cycle (e.g. streamflow, groundwater levels, withdrawals, consumptive use). As such, "assessment information" would not be expected to include information on the biological impacts of water resource use except to state instream flow "requirements" for fish and wildlife maintenance. But, while the national assessments have tended to be highly aggregated general statements of the state of water resources, "assessment information" as defined in this study may be detailed to the point of providing flow rates and usage on an individual stream or river level. Finally, both the national assessments and "assessment information" share the common tendency to view man only in the context of a net extractor of water from the hydrologic cycle. Consequently, neither would be expected to include information on the functioning of water institutions or on the economic implications of water use.

3.3 *EMPIRICAL MODELS*

With regard to the theoretical considerations of the previous chapter and the decision to adopt the demand for the National Water Assessment and "assessment information" as the empirical problem context, the two empirical models addressed in this study will now be presented. The first of these models, the assessment use model, considers those factors influencing the prior use or nonuse of the second national water assessment by water resource decision participants. The second model, the expenditure model, is concerned with those factors which influence the hypothetical expenditures of a water resource decision participant on "assessment information".

The model for use/nonuse of the second national water assessment was specified as:

$$USE = B_0 + B_1\ FEDFLD + B_2\ STATEREG + B_3\ SCINV + B_4\ REGMGT + B_5\ BUDGET + B_6\ SOCSI + B_7\ PHYBIO + B_8\ PABM + B_9\ BUDP + B_{10}\ PPP + B_{11}\ AOP + B_{12}\ ACTIVE + \varepsilon$$

Similarly, the model of hypothetical expenditures on "assessment information" was specified as:

$$EXPA = B_0 + B_1\ FEDFLD + B_2\ STATEREG + B_3\ SCINV + B_4\ REGMGT + B_5\ BUDGET + B_6\ SOCSI + B_7\ PHYBIO + B_8\ PABM + B_9\ BUDP + B_{10}\ PPP + B_{11}\ AOP + B_{12}\ ACTIVE + \varepsilon$$

3.3.1 *Definition of Variables*

In this section variables appearing in the two empirical models are defined. The two dependent variables are presented first, followed by those variables which represent organizational characteristics and finally individual characteristics. Superscripted variables were omitted from the model specifications to avoid the "dummy variable trap" of singularity which would have made estimation of the models impossible.

DEPENDENT VARIABLES:

USE	1 if respondent had used Second National Water Assessment; 0 otherwise.

EXPA	Expenditure made on "Assessment type" information. ($10,000 units)

INDEPENDENT VARIABLES:

Organization Type:

FEDHOM[a]	1 if employed by Federal Government home office; 0 otherwise.
FEDFLD	1 if employed by a Federal Government regional office; 0 otherwise.
STATEREG	1 if employed by a state or regional agency; 0 otherwise.

Agency Mission:

DVLPLN[a]	1 if agency mission was developmental-planning; 0 otherwise.
SCINV	1 if agency mission was scientific-investigative; 0 otherwise.
REGMGT	1 if agency mission was regulatory-management; 0 otherwise.

Budget:

BUDGET	Annual Division operating budget ($10,000 units).

Disciplinary Training/Background:

ENGHY[a]	1 if training was in engineering-hydrology; 0 otherwise.
SOCSI	1 if training was in social sciences; 0 otherwise;
PHYBIO	1 if training was in physical-biological sciences; 0 otherwise.
PABM	1 if training was in public administration-business management; 0 otherwise.

Organizational Responsibilities:

BUDP	Numerical percent of time devoted to budget allocation/preparation.
PPP	Numerical percent of time devoted to program planning.
AOP	Numerical percent of time devoted to agency operations.

Experience:

ACTIVE	Years of professional water resource activity.

3.3.2 *Hypotheses for Factors Affecting Use and Nonuse of the National Water Assessment*

Use or nonuse of the Second National Water Assessment was represented in the empirical model by the dichotomous qualitative variable USE. A value of one for USE indicated that the respondent had used the Second National Water Assessment while a value of zero indicated the opposite. As the dependent variable for the first of the two models considered, use or nonuse of the Second National Water Assessment is representative of the type of "lumpy" demand situations characteristic of consumer durables. In this case, based on the individual's own definition of what constituted use, he may or may not have invested his own time in becoming acquainted with the collection of information items contained in the Assessment (personal time investment is the primary cost of Assessment use since the report is freely available). Presumably, in most cases, use was interpreted as something greater than merely reading or possessing the Assessment, but actively using the information which it contains in some form of analysis or exposition.

As the model indicates, a number of factors are hypothesized to affect the probability that a water resource decision participant would have used the Second National Water Assessment. Commodity price is notably absent from the model since, for all practical purposes, the price of access to the National Assessment has been and continues to be zero. However, price would likely be an important factor influencing the demand for other information items. Factors relevant to use/nonuse of the Second National Water Assessment and their hypothesized effects are discussed in the remainder of this section.

Organizational Type - Type of organization was represented in the hypothesized empirical model of national water assessment use through two dichotomous independent variables; FEDFLD and STATEREG. A value of one for FEDFLD indicated that the individual was employed by a Federal non-headquarters (field) agency while a value of one for STATEREG indicated the individual was employed by a state or regional agency or organization. A third category of organizational type, FEDHOM representing employment by a Federal headquarters agency, was omitted from the empirical model to avoid the "dummy variable trap". Consequently, parameter estimates associated with FEDFLD and STATEREG represent effects on use of the Second National Assessment relative to the omitted category.

Expectations of the effects of organizational type upon the use of the Second National Water Assessment were that individuals employed by a Federal headquarters agency would exhibit the highest probability of having used the assessment. Individuals employed by a Federal field agency would be expected to have the next highest level of probability and State/Regional water resource decision participants would have the least probability of use among these three categories. Consequently, estimated change-in- probabilities associated with FEDFLD and STATEREG were expected to be negative.

Because the assessment has typically been highly aggregated at a regional level, its potential for use by water resource decision participants at the state level, or even at the regional level, is limited. In these types of organizations, information demand tends to be directed toward detailed information for project design and program implementation at a local or sub-basin level. This is also true, but to a lesser extent, of water resource decision participants located in field or regional branches of Federal water management agencies. While individuals employed by Federal field agencies are frequently involved in the design and implementation of localized projects and programs, the nature of their organizational ties are likely to create the need to consider the broader aspects of water management in the region over which they have jurisdiction.

Past assessments have typically provided such a general view. Individuals employed by Federal headquarter agencies, as a result of their general organizational responsibilities, are likely to have the greatest demand for information that allows them to consider broad trends in water resources.

Agency Mission - Agency mission as interpreted by the respondent was represented in the empirical model of national water assessment use by two dichotomous independent variables labeled SCINV and REGMGT. SCINV was assigned a value of one if the respondent identified the mission of his agency as primarily scientific or investigative, and a value of zero otherwise. Alternatively, REGMGT was assigned a value of one if the respondent identified regulation or management as the primary mission of his agency. A third dichotomous variable, DVLPLN, representing a developmental or planning mission was eliminated from the model to again avoid the singularity problems associated with the inclusion of all dummy categories (dummy variable trap). As such, parameter estimates and probabilities associated with SCINV and REGMGT represent effects on use of the Second National Assessment relative to the omitted category DVLPLN.

By conditioning the environment within which the water resource decision participant operates, and by narrowing the range of problem/issues he is likely to confront, the mission of an organization is expected to affect the probability that the individual would have used the national water assessment. Specifically, it was expected that being located within a developmental or planning agency would increase the probability that an individual would use the assessment. This expectation is based primarily upon the approach which past assessments have adopted. As previously discussed, past assessments have tended to employ a water budget framework in which present and projected use rates (referred to as requirements) are subtracted from expected supplies to identify potential water shortage conditions. Since a major activity of the developmental and planning agencies has been to augment supply through the construction of reservoirs and water supply projects, and to implement various water plans to avoid shortages, the focus of the assessment does much to support the legitimacy of their past actions and could be used in efforts to justify similar future activities.

In contrast, scientific or investigative agencies typically are concerned with collecting data and/or producing information for themselves or others. Consequently, an individual located in a scientific or investigative agency would be expected to have a lower probability of having used the assessment as compared to the same individual located in a developmental or planning agency. Similarly, individuals employed by regulatory or management agencies are also less likely to use the national assessment. For the most part, water resource regulatory agencies are concerned with potential violations of water quality standards or violations of administrative water rights. In the first instance, the general lack of water quality information in past assessments would lead one to conclude that the assessment should hold little utility for the individual concerned with water quality regulation. In the second instance, lack of detailed information on water use would limit the probability that an individual responsible for monitoring water rights violations might use the national water assessment. Consequently, SCINV and REGMGT were expected to exhibit negative changes in the probability of using the Second National Assessment as compared to the omitted DVLPLN.

Budget - The final organizational characteristic included in the empirical model of national water assessment use, BUDGET, was defined as the annual operating budget of the respondent's immediate branch or division. Expressed in

$10,000 units, BUDGET is representative of the resources available to the water resources decision participant in performing his professional responsibilities. As the budget of a division or branch of an organization increases, the division's ability to allocate greater resources to data collection and information production also increases. With this increased capability the division or branch can obtain information that more closely suits its own special needs. If the nature of its responsibilities demand highly accurate information, resources can be allocated to improve accuracy. If information of a highly specific nature is needed, this too may be pursued. Whatever the case may be, a larger division or branch budget tends to make water resource decision participants within that division or branch less dependent on generally available water resource information, such as the national water assessment, which may be less suited to their particular needs. As a result, increases in BUDGET were expected to have a negative impact on the probability of using the national water assessment.

Disciplinary Training/Background - As an individual-specific characteristic, disciplinary training/background was represented in the empirical model through the use of three dichotomous independent variables labeled SOCSI, PHYBIO, and

PABM. SOCSI represented training in the social sciences (economics, law, and other social sciences). PHYBIO represented training in the physical or biological sciences, while PABM indicated that the respondent's professional training was in the area of public administration or business management. A fourth category of disciplinary training, ENGHY represented training in engineering or hydrology. This category was eliminated from the empirical model specification and consequently parameter estimates and probabilities associated with SOCSI, PHYBIO, and PABM must be interpreted relative to ENGHY.

Contrary to what might be initially assumed, individuals having professional training in engineering or hydrology were expected to have a lesser probability of having used the Second National Water Assessment as compared to those having training in the other areas considered. For example, one might conclude that since the national water assessments have tended to adopt a water balance framework based upon the hydrologic cycle model, hydrologists and engineers who deal with hydrologic problems would find the information contained in the assessment in correspondence with their needs and disciplinary outlook. While the information contained in the assessment clearly agrees with the hydrologist's perspective, and is derived from hydrologic data, it tends to be more a product of hydrologists than something they would be expected to use themselves. The reason behind this goes again to the assessment's level of generality. Because the assessment has typically been a highly aggregated informational product, it is not particularly well-suited to the majority of the work done by hydrologists and engineers.

Conversely, the other areas of training captured in the empirical model were expected to impact the probability of Second National Water Assessment use in a positive manner relative to ENGHY. This was expected to be especially true of those individuals possessing training in public administration and business management. As a result of their training and interests, it appears likely that these individual's would be more likely to assume administrative positions in water management agencies than those with training and interests in the physical/biological sciences or the social sciences. Further, to the extent that occupying such positions generates a demand for broad trend information useful for determining agency orientations and for its symbolic value in supporting legislation and appropriations, the probability of use of the Second National Assessment would be expected to be greater for those with public administration-business management training. Consequently, with respect to the empirical model, a positive probability (relative to ENGHY) is expected to be associated with SOCSI, PHYBIO and PABM.

Organizational Responsibilities - As the theoretical and empirical models indicate, the responsibilities an individual has within an organization are expected to influence his demand for information and the characteristics of information. For example, as an individual is promoted to higher levels within an organizational hierarchy, responsibilities normally increase in importance while becoming more generalized. Instead of having responsibility for one or more individual projects, accounts, etc., the individual occupying a higher hierarchical position may be charged with the administration of an entire program composed of multiple projects. As a result of this shift in responsibilities, the nature of the individual's demand for information also shifts, presumably becoming more generalized and less directed toward the type of detailed information typically required for individual design or investment decisions. Moreover, while a particular organization may be charged with the management of water resources, not all responsibilities within that organization are directly linked to water management or require water resource information (ex. personnel management).

Making operational the concept of organizational responsibilities proved to be difficult. While a number of possible operationalizations including such approaches as employing the individual's GS level (applicable only to Federal employees), and the individual's numerical hierarchical position relative to the highest position in his branch or division were considered, each was rejected owing to incompleteness or inconsistency across organizations. Ultimately, it was determined that eliciting the percentage of time the individual devoted to four general areas of professional responsibility would provide a satisfactory operationalization. These four areas included: budget allocation/preparation activities (BUDP), research and development (RADP), program planning (PPP), and agency operations (AOP). Because the sum of the percentages for these four areas of responsibility would nearly always equal 100 percent,[7] creating singularity problems for estimation, RADP was omitted from the empirical model specification. Consequently, the empirical determination of the effect of organizational responsibilities of the individual upon the probability of using the Second National Water Assessment was left to the

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[7] In addition to the four categories presented, a fifth miscellaneous category was included on the questionnaire (Appendix B). Consequently, for a very few respondents, the four categories BUDP, RADP, PPP, and AOP summed to something less than 100 percent.

three remaining responsibility areas.

Expectations of the effects of marginal changes in percentage of time devoted to the various responsibility areas upon national water assessment use were based on the potential contribution the assessment would have to the discharge of those responsibilities. With respect to percentage of time devoted to budget preparation, it was expected that as an individual devoted more professional time to this responsibility, his probability of using the assessment would decline. This same expectation was also hypothesized for percentage of time devoted to agency operations since the information contained in the national water assessment is largely irrelevant to these responsibilities. Alternatively, as the percentage of time devoted to program planning activities increases, the probability of assessment use by the individual was expected to increase. While the level of detail found in the information appearing in past assessments has typically not been precise enough upon which to base specific project or program design, the assessment's broad view of water resource problems would be expected to be useful for program planners in scanning for potential problems and for project justification.

Experience - The final individual-specific characteristic considered in the empirical model of national water assessment use was personal experience in water resources management. As a proxy for this concept, number of years of professional activity in water resource issues was chosen and included in the model as the continuous independent variable labeled ACTIVE.

Since years of activity in water resource issues was expected to be highly correlated with advanced positions within the organizational hierarchy, an increase in years of activity was hypothesized to increase the probability of national assessment use, *ceteris paribus*. The reasoning behind this expectation, discussed previously under organizational responsibilities, concerns the nature of individual responsibilities as an individual ascends the organizational ladder and the effect this has upon his informational demands. At higher levels within the organizational hierarchy, responsibilities normally increase in importance while becoming more generalized. As a result of this shift in responsibilities, the nature of the individual's demand for information also shifts. Instead of demanding detailed information suitable for specific investments, the individual's tends to demand information which will give him the broad view of water resource issues which the assessment has traditionally supported. Therefore, increases in ACTIVE were expected to be associated with positive changes in the probability of using the Second National Water Assessment.

3.3.3 *Hypotheses for Factors Affecting Expenditures on Assessment Information*

Expenditures on assessment information was represented in the second hypothesized empirical model by the continuous variable EXPA. Because of the structure of the method used to elicit this dependent variable, its value was constrained within the range of zero to 100, representing $10,000 units of expenditure. As the dependent variable for the second of the two models considered, expenditures on assessment information items is similar to Engel function analysis except that, rather than investigating changes in expenditures on a commodity group as income varies, the emphasis is placed on investigating changes in expenditures as personal and organizational characteristics vary subject to a fixed level of income.

As the model indicates, a number of factors are hypothesized to affect expenditures for assessment information. These factors, and their hypothesized effects are discussed in the remainder of this section.

Organizational Type - Conclusions drawn from the conceptual model of the demand for information by decision participants located in complex organizational settings were not specific with regard to expectations of the effects of organizational type upon expenditures made for "assessment information". Unlike previous use of the Second National Water Assessment in which individuals employed by a Federal headquarters agency were expected to exhibit the highest probability followed by individuals employed by a Federal field agency and those located in a state or regional organization, organizational type would seem to have little effect on the "demand for assessment information" as defined. However, due to the explorative nature of the analysis, the two dichotomous independent variables FEDFLD and STATEREG were included in the model to test the general hypothesis that organizational type influences expenditures.

Agency Mission- As stated previously, agency mission tends to condition the environment within which the water resource decision participant operates. It does this by narrowing the range of problem/issues he is likely to confront, and by casting those problems in a form amenable to the agency's perception of what it can and should do. Accordingly, developmental agencies seek to develop resources and as such will demand information that will support development. Regulatory agencies seek to regulate and, consequentially, will tend to demand information that supports regulation efforts. In the Missouri River Basin context of competition between instream and offstream uses, individuals in developmental/planning agencies would be expected to spend relatively more on "assessment information" than individuals located in scientific/investment or regulatory management agencies. Consequently, SCINV and REGMGT were expected to be negatively related to expenditures made for "assessment information" as compared to the omitted DVLPLN.

Budget - In the contingent expenditures exercise included in the survey of Missouri River Basin water resource decision participants were constrained to a budget of $100,000. As a result, division or branch annual operating budget in the present specification is more indicative of the size of the respondent's immediate organizational unit than it is representative of the resources available to the respondent. No specific expectations were held for the effect of division or branch budget on expenditures for "assessment information", but this variable was retained in the model to test the general hypothesis that division size affects level of expenditure on assessment information.

Disciplinary Training/Background - By structuring the individual's perceptions of appropriate solutions to water resource problems and by implying acceptable methods for analyzing those problems, disciplinary training is expected to have the greatest effect of the variables considered upon expenditures made on "assessment information". As inputs to the analysis of a water resource problem, "assessment information" most closely parallels the disciplinary orientation of hydrologists and engineers who deal with water resource issues. Accordingly, individuals with professional training in engineering or hydrology were expected to spend the most on "assessment information". Alternatively, due to the strong but differing disciplinary paradigms of the social sciences and the physical/biological sciences, individuals trained in these area were expected to spend relatively less on "assessment information" and consequently more on economic-institutional and chemical-life related information respectively. Additionally, compared to individuals trained in hydrology and engineering, water resource decision participants with backgrounds in public administration/business management were expected to have smaller expenditures on "assessment information". Consequently, with respect to the empirical model, a negative relationship (relative to ENGHY) is expected to be associated with SOCSI, PHYBIO and PABM.

Organizational Responsibilities - As with organizational type and division or branch budget, no prior expectations were hypothesized with respect to the effect of organizational responsibilities on expenditures levels for this particular category of information. Had another categorization been employed, this might have differed considerably. However, the three continuous variables representing an individual's distribution of organizational responsibility were retained in the model to test the hypothesis that organizational responsibilities are significantly related to expenditures on "assessment information".

Experience - No *a priori* effect was hypothesized for years of experience in water related issues on "assessment information" expenditures. As in the previous instances, this variable was included in the model to empirically determine if an effect was detectable, and if so to attempt to offer reasons why this might be so.

3.4 *SURVEY ONE*

Because of the absence of previous empirical work to guide the expectations and procedures employed in this study, it was determined that to adequately test the empirical models relating National Water Assessment use and expenditures made for "assessment information" to individual and organizational characteristics, a two-part sequential survey approach was required. Using this approach, an initial survey could be undertaken to determine the viability of the proposed models and survey techniques. Based upon the results of this first survey, a second survey could then be instituted. If results of the initial survey were poor, the experience gained would provide an opportunity to modify the survey instrument and/or the models which might still allow plausible conclusions to be drawn. If, on the other hand, results of the initial survey were successful, a second survey could provide additional evidence upon which to judge the models.

Given this survey strategy, the choice of an initial survey of water resource decision participants was necessary. While such a survey, with regard to some generally known water resource issue, might have been made of a random sampling of decision participants across the U.S., it was determined that the survey should be conducted within a river basin management issue context. Consequently, a particular river basin and relevant water management issue combination was selected, after which water resource decision participants at the federal, regional, and state level having management responsibilities within that region were contacted.

The choice of a river basin management context as the appropriate survey focus was based upon consideration of current directions in U.S. water resources management. A clear understanding of these directions requires that the changing role of the Federal agencies be established. Consequently, a brief discussion of the evolution of Federal management of national water resources is presented in the following section.

3.4.1 *The Evolving Role of Federal Water Resource Management*

As the introductory material in Chapter 1 indicated, while the Federal role in water resources management remains considerable, the nature of that role has undergone significant change. Much of this change has taken place over the past two decades and will continue to influence water resources management for the foreseeable future. Clearly, to define in a detailed way the Federal role in water resources management in the present and future would be an impossible task. However, an examination of historical trends in U.S. water management including the historical Federal role may permit recognition of the institutional context within which consideration of water information demand and data system design must proceed.

In the early portion of this century, there arose a general consensus that Federal management of the nation's water resources, primarily through water project construction, was not only necessary but entirely proper. Reinforced by the confluence of a series of severe droughts and floods, and by the intellectual remnants of the early conservation movement which favored water resource development as a way to conserve other resources, the Federal construction agencies (Corps of Engineers, Bureau of Reclamation, and the Soil Conservation Service) assumed a dominant role in water resources planning and management.

> In summarizing the thinking of that period Gilbert White articulated what Wengert later called the "pure doctrine" of river basin development. This pure doctrine included three elements: the multiple purpose water storage project, *an integrated system of projects within river basins*, and the goal of using water resources management to direct regional development (Shabman, 1984, p. 205).

As a result of this view, coordinated planning and development based upon a river basin focus was maintained to be a primary goal and method of Federal management. However, as Shabman (1984) indicates, "Rarely were project studies initiated or designed consistent with a river basin planning process (p. 205)". Rather, because Federal water planning and water project development was exercised through the Federal construction agencies, individual project studies were initiated primarily in response to requests from local congressional representatives seeking to resolve politically articulated water problems. Consequently, the goal of a river basin planning process was never truly realized, being replaced instead by a fairly uncoordinated individual project level planning process.

As a result of the project level planning process which typified federal water resource management, by the 1960s the Federal government had established a large capital stock of dams and water delivery systems. But with the approach of the mid 1960s and 1970s, public and financial support for traditional water development waned. As the nation moved into the 1970s, the concept of a capital stock in water resources was no longer limited to engineering works, but expanded to include remaining free flowing rivers and the environmental amenities associated with them. Consequently, the traditional federal water investment program began a rapid decline (Caulfield, 1982). In light of these developments the Federal water management agencies are beginning to adopt the view that present and future water management must focus upon the management of existing capital water stocks which will rely much more upon the management of demand than upon the augmentation of supply.

As a result of these occurrences, two primary themes are expected to define a new future Federal role in water resources management. First, there will emerge a renewed Federal commitment to the river basin as the focus of water management, coincident with the decreasing emphasis on individual water project construction. Second, due to this renewed focus, increasing pressure will be placed on Federal agencies to change operating rules and storage allocation in projects to serve new users in a basin-wide context.

As a result of the changing focus of Federal water resources management, and the new responsibilities this focus will place on the Federal water management agencies, the water information and data system will undoubtedly also have to evolve if it is to, as discussed at the beginning of Chapter 2, remain externally consistent. In the present study, this changing institutional context is recognized and provides the specific focus for considering the demand for water resources information. Therefore, the river basin was selected as the delineating factor for the survey of water resource decision participants.

3.4.2 *The Missouri River Basin*

For purposes of compiling and analyzing water resources data, the Water Resources Council in 1970 established 21 major U.S. water resources regions. One of these, the Missouri River Basin, encompasses fully one-sixth of the conterminous United States. Including all of Nebraska, and parts of Montana, Wyoming, North Dakota, South Dakota, Colorado, Iowa, Minnesota, Kansas and Missouri (Figure 3.1), the Missouri River Basin drains approximately 511,000 square miles in the U.S. and an additional 9,700 squares miles in Canada.

While the Missouri River Basin is clearly vast and, as a result quite diverse in terms of geology, topography, and climate, the region has for some time had a fairly strong sense of basin identity with respect to water issues. To a large extent, this is the result of the region's primary orientation toward agriculture in both its economy and water use, and to the unifying influences of the Missouri River Basin commission,[8] an organization composed of the 10 member states listed above, and 10 Federal agencies involved in management of the basin's water resources. The existence of a basin identity would be expected to enhance response rates to a survey designed around a basin management issue.

As the result of a previous study of water-use information needs done for the Missouri River Basin Commission (Kirkham, Michael and Associates, 1981), names and addresses of water resource decision makers in the Missouri River

[8] The Missouri River Basin Commission is no longer in existence. However, its functions have largely been assumed by the newly created Missouri River Basin States Association.

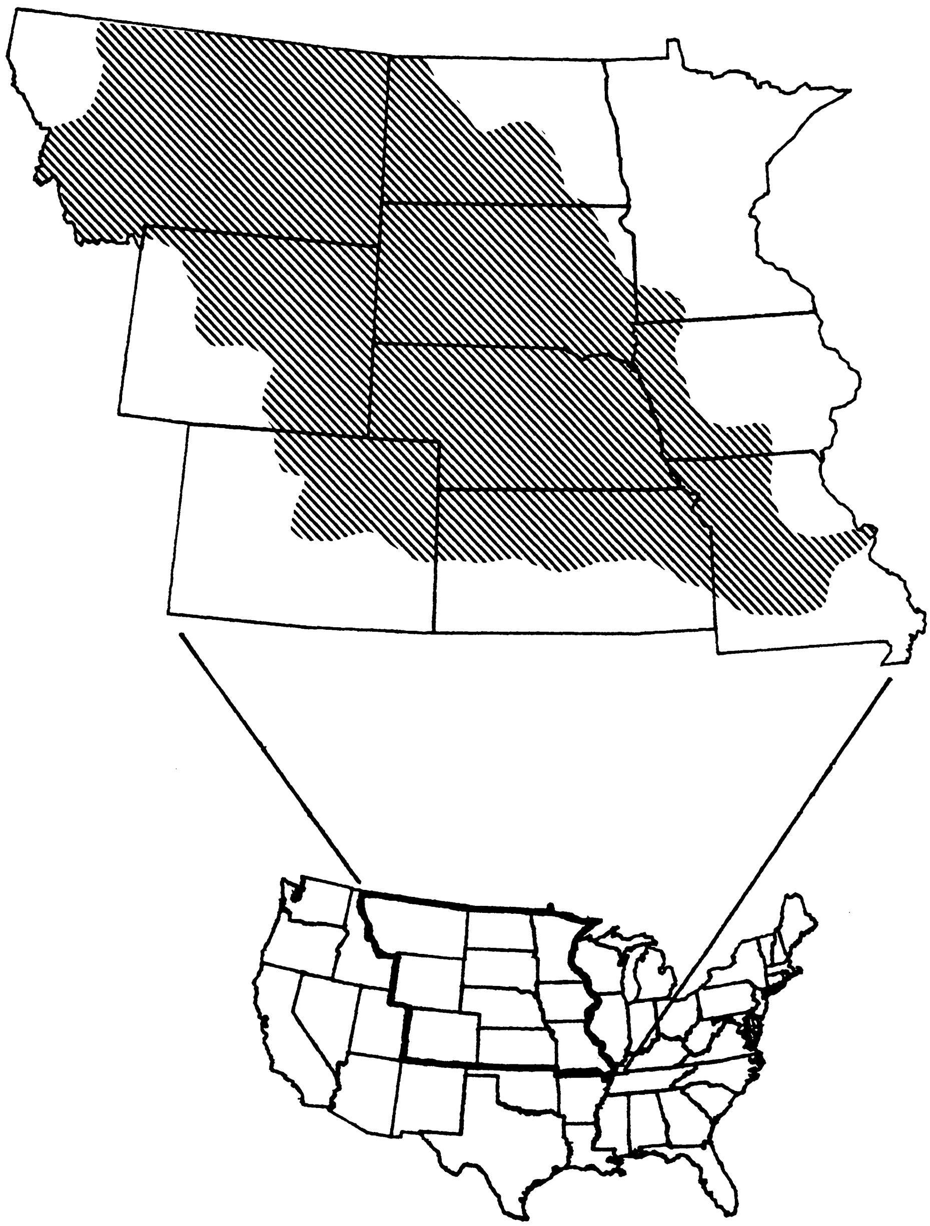

Figure 3.1: The Missouri River Basin

Basin were readily available, This fact, coupled with the regional identity of the Basin, and the preconditioning effect of the previous study suggested the Missouri River Basin as a likely candidate for the initial survey of this study's two-part survey strategy.

While the Water Resource Regional Report of the Second National Water Assessment identified a number of water resource issue/problems relevant to the Missouri River Basin,[9] many of these issues tended to be centered on the problem of increasing competition between instream water uses and offstream uses. Instream uses include navigation, hydro-power production, fish and wildlife maintenance, while the major offstream diversions include irrigation, industrial use, municipal use, and steam-electric power generation. To the extent that offstream diversions increase as a result of economic development and increases in population, less water remains for the support of instream uses which have generally been considered subordinate to the traditional offstream uses under State water rights law.

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[9] Issues identified included uncertainty over unresolved Indian and Federally reserved water rights, water demands of energy exploitation, municipal/industrial water needs, instream flow needs, water-related recreational needs, navigational water needs, interbasin water transfers, flooding and floodplain management, erosion, and water quality.

Because of the extent to which instream-offstream water competition summarized many of the problem/issues presented for the Missouri River Basin, and because this issue was expected to be less likely to evoke strong emotional reactions which might translate into low survey participation and/or unreliable responses, instream-offstream water competition was selected as the issue context of the survey of Missouri River Basin water resource decision participants.

3.4.3 *The Survey*

Data used in the empirical analyses of the initial survey were obtained through a mailed questionnaire survey of approximately 200 state, regional, and federal water resource decision makers having responsibilities in the Missouri River Basin.[10] The Survey was conducted using the Total Design Method (Dillman, 1978) during the period August 29 - October 15, 1985. The Total Design Method is an integrated approach to survey design which stresses the integration of all the components of conducting a survey including questionnaire format, question wording, timing of correspondence, etc.

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[10] This data is contained in Appendix E.

In all, respondents could have been contacted by mail on three separate occasions (Appendix A). Initially, a letter describing the purpose of the survey and requesting assistance, along with a copy of the questionnaire, was sent to each potential respondent. One week later, a postcard was mailed to each respondent reminding him of the survey and thanking him for his assistance. Finally, after the passing of a four week period, those individuals who had not responded were sent a second letter requesting their assistance and another questionnaire. Names and addresses of potential respondents were obtained from a number of sources which included a listing of USGS State-Federal Cooperators, the Federal Directory, and a list of respondents from a Missouri Basin survey conducted in 1979 for the U.S. Geological Survey (1981). Of the 200 questionnaires originally mailed, 149 were eventually returned resulting in a response rate of 75 percent. Forty of the returned questionnaires were eliminated from the empirical analysis due to missing information. As a result, the following analyses were based upon the remaining 109 observations.

3.4.4 *The Questionniare*

The instrument developed for surveying Missouri River basin water resource decision participants was composed of three main sections each having a specific function and goal. Section number one of the questionnaire, which included the first two pages (Appendix B), was the section most likely to be scanned by the respondent prior to his participation. Consequently, in order to maximize the probability that the respondent would complete the questionnaire, the questions presented in this section were intended to gain the interest of the respondent and reinforce the message that his opinions were considered important. Toward this end, questions requesting the respondent's past use of and satisfaction with the "Federal Water Data System" and the Second National Water Assessment were included.

Section two of the questionnaire presented the respondent with two hypothetical situations. The first of these, the contingent ranking exercise, was designed to enable the ultimate estimation of marginal information item values. The contingent ranking exercise will not be presented at this point but will be fully covered in Chapter 4. The second situation, a hypothetical expenditure exercise, was designed to provide the data necessary to relate personal and organizational characteristics to expenditures made on "assessment information".

In the hypothetical expenditure exercise, the respondent was asked to assume that his organization had made him responsible for analyzing the instream/off-stream water use competition problem in the Missouri River basin and for making policy recommendations. Additionally, the respondent was to assume that no appropriate information concerning this problem was previously available to him. Given these conditions, the respondent was asked to assemble his most preferred information system from a list of 18 information items and associated costs. To add realism to the exercise, the respondent was instructed that a budget of $100,000 for information acquisition had been made available to him. He could allocate this budget across the available information items in any manner he wished, but he was not to exceed the $100,000 limit. Among the information items were those which, unknown to the respondent, fit the category of "assessment information" and others, such as economics and biological information, which clearly do not fit the categorization. Criteria used to establish costs for the information items were; 1) to attempt to accurately represent the relative costs of the different types of information, and 2) to provide the respondent with balanced expenditure opportunities across "assessment" and "non-assessment" information. Based upon the selections of the respondent, expenditure made for "assessment information" was calculated and served as the dependent variable for the expenditure model.

Section three of the questionnaire, comprised the last section of the questionnaire. In this section, questions designed to elicit personal and organizational characteristics of interest were presented to the respondent. Following this section, the final page of the questionnaire was left open to allow the respondent to comment on the questionnaire, public water data collection priorities, or other insights or concerns.

A complete presentation and discussion of simple descriptive statistics for model variables which characterize the sample group is included in Appendix D.

3.4.5 *Estimation of National Water Assessment Use*

Because of the discrete nature of the dependent variable in the empirical model of national assessment use (USE equals one if respondent had used the Second National Assessment; USE equals zero otherwise), ordinary least squares (OLS) estimation of this type of qualitative choice model is often considered inappropriate. More commonly referred to as the Linear Probability Model, OLS estimation of a model with a discrete endogenous variables suffers from a number of deficiencies. "First, the variance of the disturbance term of the model is heteroscedastic. The presence of heteroscedasticity results in loss of efficiency of the parameter estimates; and, because of the heteroscedasticity problem, the standard errors of the ordinary least squares (OLS) parameter estimates are biased. Second, the distribution of the disturbance term is not normal (Pindyck and Rubinfeld). As such, the classical statistical tests of significance are not applicable because the tests depend on normality of the disturbance terms. Third, and perhaps most importantly, this formulation allows (predicted probabilities) to fall outside the interval between 0 and 1, inconsistent with the interpretation of the conditional expectation as a probability (Capps and Kramer, 1985, p. 50)."

Fortunately, alternative specifications have been developed which circumvent the deficiencies of the linear probability model. Amemiya (1981) identifies the most commonly used of these as the probit model and the logit model. Each of these models, through the use of a monotonic transformation, guarantee that all predicted probabilities will lie in the 0-1 interval overcoming the most troubling deficiency of the linear probability model. The probit model is based upon the use of the standard cumulative distribution function while the logit model is associated with the logistic cumulative function. According to

Amemiya, "Because of the close similarity of the two distributions . . . it does not matter much whether one uses a probit model or a logit model, except in cases where data are heavily concentrated in the tails due to the characteristics of the problem being studied (1981, p. 1487). Moreover, Capps and Kramer (1985) found that in a direct comparison of probit and logit results, "differences in empirical performance between the respective models were indeed minimal (p. 58)". As a result, the logit specification was chosen for the estimation of the national assessment use model.

For the logit model, the probability that the *i*th individual had used the Second National Water Assessment is given by:

$$P_i = F(z_i) = e^{zi} / (1 + e^{zi})$$

where:

$$-\infty < z_i < \infty$$

$$z_i = X'_i\beta.$$

Here, $X'_i\beta$ is the vector of the individual's personal and organizational characteristics times the vector of parameter estimates.

In logit analysis, coefficients are typically estimated through the method of maximum likelihood assuming normality of the disturbance terms. "The objective is to find the estimator that maximizes the likelihood of observing the pattern of choices in the sample. Although the maximum likelihood estimation procedure requires the use of iterative algorithms, this procedure assures the large-sample properties of consistency and asymptotic normality of the parameter vector so that conventional tests of significance are applicable (Capps and Kramer, 1985, p. 50)".

While the parameter estimates obtained through maximum likelihood estimation of the logit model are amenable to conventional tests of significance (Student's T-Test), the values of the estimates do not represent the expected change in the dependent variable as a result of an incremental change in the independent variable of interest as is the case for OLS estimates. To obtain the change in the probability of national assessment use for a small change in a personal or organizational characteristic, differentiation of equation 4.4 indicates that the maximum likelihood estimate must be scaled by the value of the underlying density function $f(z_i)$ associated with each possible value of the underlying index z_i. Normally this is accomplished by substituting the sample means for each of the independent variables into the estimated empirical model and multiplying to obtain the index z_i. The value of the density function associated with this index is then calculated as:

$$f(z_i) = e^{zi} / (1 + e^{zi})^2$$

Finally, each parameter estimate is multiplied by $f(z_i)$ to obtain the change in the probability of use resulting from an incremental change from the sample means in an independent variable.

Numerous criteria exist for assessing the success or failure of a qualitative choice model. Similar to the F-test of OLS estimation, the likelihood ratio test considers the joint hypothesis that all parameter estimates are equal to zero. As such, the likelihood ratio test assesses the significance of the overall estimation. Comparing the likelihood ratio statistic to the appropriate Chi-square value having the same degrees of freedom permits one to either reject or fail to reject the null hypothesis. Rejection of the null hypothesis indicates that the model is significant (at least one independent variable is significant).

Several measures of goodness-of-fit have typically been used in models of qualitative choice including the traditional coefficient of determination (R^2). Traditional R^2 is calculated as the sum of squares of the regression divided by the total sum of squares. Since observed values of the dependent variables are always zero or one, while predicted probabilities tend to lie somewhere within this interval, traditional R^2s for models of qualitative choice are seldom large. Accordingly if the coefficient of determination is to be used as a measure of goodness-of-fit, it must be realized that its upper limit is likely to be substantially less than one (Morrison (1972), Neter and Maynes (1970)). Morrison (1972) provided an approach to estimating the expected upper limit on R^2 assuming the predicted probabilities follow a beta distribution. This approach involves determining the mean and variance of the model predicted probabilities and, through the use of the method of moments, calculating the values α and β which summarize the beta distribution. Following the calculation of these parameters, the upper bound of R^2 is:

$$R^2 \text{ upper bound} = 1 / \alpha+\beta+1$$

According to Capps (1983), "The ratio of the empirical R^2 to the estimate of the upper bound for R^2 provides a suitable indicator of goodness-of-fit (p. 36)".

In addition to traditional R^2, two other goodness-of-fit scalars have been used in qualitative choice models: Efron's R^2, and McFadden's R^2. Efron's R^2 is the squared correlation coefficient between the binary dependent variable and the predicted probabilities. McFadden's R^2, on the other hand, is calculated as $1 - (\ell_{(B_{ml})}/\ell_0)$, where ℓ_0 is the value of the log-likelihood function subject to the constraint that all regression coefficients except the constant term are zero, and $\ell_{(B_{ml})}$ is the maximum value of the log-likelihood function without constraints.

Another method of assessing the goodness-of-fit of a model of qualitative choice involves the extent to which the estimated model correctly classifies respondents. In this method, individual predicted probabilities are compared to actual use or nonuse. With respect to the model under consideration and using a 50:50 classification scheme, a predicted probability of 50 percent or more indicates that the individual would have been expected to have used the Second National Assessment. A predicted probability of less than 50 percent alternatively indicates that the individual would have been expected to have not used the assessment. To the extent that the implications of the predicted probabilities correspond to the observed behavior, the decision is correctly classified. Consequently the percentage of respondents correctly classified is representative of the predictive ability of the model.

3.4.6 *Estimation of Expenditures for Assessment Information*

In order to accurately simulate the budget constrained information choice problem, the contingent expenditure exercise posed in the survey of Missouri River Basin water resource decision participants (Q-8, Appendix B) asked that the respondent allocate a fixed budget of $100,000 among 18 assorted water information items. Based upon his responses, the amount of expenditure allocated for "assessment information" items was tallied and serves as the dependent variable in the expenditures model. Clearly, due to the constraining effect of the fixed budget, expenditures on "assessment information", EXPA, could not be expected to exceed $100,000. Similarly, since the opportunity did not exist to spend negative amounts on information items, EXPA could be no less than zero indicating that none of the fixed budget had been allocated to "assessment information". Consequently, as a result of the structuring of the contingent expenditures exercise, the dependent variable EXPA is subject to both a lower and an upper bound.

Given a limited dependent variable, using ordinary least squares (OLS) *may* not be the most appropriate technique for estimation. For this reason, Tobit analysis was first introduced by James Tobin in 1958. Tobit analysis, which can be regarded as a synthesis of multiple regression analysis and probit analysis, is typically used in instances where the dependent variable is subject to a lower limit, and upper limit, or both. Its use allows the explanation of variations within the bounded area (multiple regression function), as well as the probability of being at the bounds as opposed to within the bounded area (probit function). As McDonald and Moffit explain in the case of one lower limit, "The Tobit model provides not only probable changes in the magnitude of the dependent variable if it is already above the limit, but also changes in the probability of being above the limit (1980)". Clearly then, use of the Tobit model is to some extent predicated upon the existence of observations at the limits which require explanation. In fact, Tobin (1958) discusses the importance of limit observations in the following way:

> Account should be taken of the concentration of observations at the limiting value when estimating statistically the relationship of a limited variable to other variables and in testing hypotheses about the relationship. An explanatory variable in such a relationship may be expected to influence both the probability of limit responses and the size of non-limit responses. If only the probability of limit and non-limit responses, without regard for the value of non-limit responses were to be explained, probit analysis provides a suitable statistical model. But it is inefficient to throw away information on the value of the dependent variable when it is available. *If only the value of the variable were to be explained, and there were no concentration of observations at a limit, multiple regression would be an appropriate statistical technique*. (p. 25, emphasis added)

Accordingly, the mere existence of limits on the value of the dependent variable is not sufficient to require the use of Tobit analysis. Equally important is the extent to which responses are clustered at those limits. According to Tobin, a *substantial* number of responses should take on the limiting value(s) for Tobit analysis to be indicated. If no such concentration is observed in the pattern of responses, there is no need to explain probabilities associated with being at or away from the limit, and multiple regression techniques are appropriate.

Following a review of the distribution of responses to the contingent expenditure exercise, it was discovered that in only three of the 109 cases was EXPA equal to a limit (one at $0; two at $100,000). Since this did not seem to be a substantial number of respondents, ordinary least squares (OLS) was employed as the technique of estimation for the expenditures model.

3.4.7 *Results of National Water Assessment Use Model*

Results of the maximum likelihood estimation of the empirical model of national assessment use are exhibited in Table 3.1

The logit model required four iterations to generate the estimated parameter coefficients at a convergence toler-

TABLE 3.1

Maximum Likelihood Estimates for Assessment Use Model - Missouri River Basin

VARIABLE	ESTIMATE	CHANGE IN PROB[a]	T-RATIO
INTERCEPT	.69387		.57916
FEDFLD	-.38799	-.0760399	-.46974
STATEREG	-1.3876	-.2719477	-1.9834
SCINV	-1.2964	-.2540739	-1.6347
REGMGT	-1.0295	-.2017657	-1.9855
BUDGET	.0000108	.0000021	.08013
SOCSI	.40517	.0794069	.45669
PHYBIO	-.63536	-.1245205	-.71324
PABM	1.4354	.2813157	2.1915
BUDP	-.05787	-.0113416	-1.4487
PPP	-.005078	-.0009952	-.40014
AOP	-.0071	-.0013915	-.69727
ACTIVE	.04691	.0091936	1.6817

[a] Computed at Sample Means

Log of Likelihood function = -56.116 in 4 iterations.
R-Square = .1919
Upper Bound on R-Square Assuming Beta Distribution = .2049
Ratio of R-Square to Upper Bound = .9365
Efron's R-Square = .1918
McFadden's R-Square = .1705
Likelihood Ratio Test = 23.07 with 12 degrees of freedom.
72.5 percent respondents correctly classified.
Probability of Use at Sample Means = 26.8 percent.

ance of 0.001. Inspection of the summary statistics presented toward the bottom of the Table indicate an empirical R^2 equaling 0.1919. While this may seem low, when compared to the upper bound on R^2 of 0.2049 assuming a beta distribution for the predicted probabilities (Morrison, 1972), empirical R^2 is approximately 94 percent of the maximum that could reasonably be expected. In turn, Efron's R^2 (0.1918) and McFadden's R^2 (0.1705) were both reasonable close to empirical R^2. With a likelihood ratio test of 23.07 with 12 degrees of freedom, the null hypothesis of nonsignificance of the model was rejected. Information concerning the predictive ability of the model was investigated using a 50:50 classification scheme. Approximately 72.5 percent of the respondents were correctly classified by the model as to their use or non-use of the Second National Water Assessment. The probability of an individual using the Second National Assessment at the sample means was calculated to be approximately 27 percent.

Inspection of the parameter estimates and calculated changes-in-probability generally confirms *a priori* expectations. As expected the logit analysis indicated that an individual employed by a state or regional water resource organization was significantly less[11] likely to have used

[11] For this and all following tests of significance, a significance level of .10 was chosen.

the Second National Assessment as compared to a similar individual employed by a Federal headquarters organization. In fact, state/regional water resource decision participants were shown to, *ceteris paribus*, be 27 percent less likely to have used the water assessment. The probability of assessment use by individuals employed by a Federal field organization was not significantly different from that of individuals located in Federal headquarters agencies.

As expected, the logit analysis further indicated that an individual employed by an organization with a scientific/investigative or regulatory/management mission had a significantly lower probability of assessment use relative to an individual located within a developmental/planning agency. The extent of the effect was somewhat larger for the individual operating within a scientific/investigative mission, decreasing the probability of assessment use by 25 percent. Employment by an organization with a regulatory/management mission decreased the probability of assessment use, *ceteris paribus*, by approximately 20 percent. Division or branch annual operating budget did not significantly increase or diminish the probability of assessment use.

With regard to personal characteristics of the water resource decision participant, individuals with more years of professional activity in water resource issues and those possessing professional training in the area of public administration/business management, had significantly higher probabilities of national water assessment use than those with less years of professional water resource activity and those with training in engineering or hydrology. Consistent with *a priori* expectations, the change-in-probability associated with ACTIVE indicated that increasing experience in water resource issues by one year, *ceteris paribus*, resulted in just less than a one percent increase in the probability of assessment use.

The change in probability associated with PABM indicated that an individual with professional training in public administration/business management was 28 percent more likely to have used the assessment than a similar individual with training in engineering or hydrology. Professional training in the social sciences and the physical/biological sciences had no significant effect on the probability of assessment use relative to a background in engineering or hydrology. Additionally, professional responsibilities of the individual, as defined by BUDP, PPP, and AOP, had no significant impact upon the probability of use of the Second National Water Assessment.

3.4.8 *Results of Expenditures for Assessment Information Model*

Results of the ordinary least squares (OLS) estimation of the empirical model of expenditures on "assessment information" items are exhibited in Table 3.2

As the summary statistics indicate, the F-value for this model of 2.752 allowed rejection of the hypothesis that all slope coefficients for the model were equal to zero. Accordingly, the amount of variation explained by the model was significant. R^2 for the model was .2559, implying that approximately 26 percent of the total variation in expenditures was explained by the model. While this may not seem large, it must be remembered that data for the model was obtained through a cross-sectional sample of individual water resource decision participants. Typically in such instances a low R^2 may occur, even if the model is a satisfactory one, because of the large variation across individual units of observation inherent in the data. On the basis of prior experience it is generally agreed by researchers that with cross-sectional sample data an R^2 of .20 is, from a statistical standpoint, considered satisfactory. However, for actual policy or investment decisions, this level of model performance may or may not be satisfactory depending upon those involved in the decision process and the issue under consideration.

TABLE 3.2

OLS Estimates of Expenditure Model - Missouri River Basin

VARIABLE	ESTIMATE	T-RATIO
INTERCEPT	7.875887	7.393
FEDFLD	-0.831752	-1.095
STATEREG	-0.738540	-1.199
SCINV	0.160818	0.248
REGMGT	-0.485080	-1.050
BUDGET	0.000227	1.825
SOCSI	-0.687560	-0.873
PHYBIO	-0.886409	-1.512
PABM	-1.165212	-2.046
BUDP	-0.090750	-2.877
PPP	-0.011736	-1.049
AOP	0.003774	0.429
ACTIVE	-0.020863	-0.855

F-Value = 2.752
R-Square = .2559
Collinearity Diagnostics Negative.
Heteroskedasticity Diagnostics Negative.

In order to correctly apply the classical regression model, a number of assumptions about the model and the data going into the model must be met. Among these assumptions are; 1) there exists constant error variance across observations, and 2) there exists no exact linear relationship between any two or more independent model variables. The violation of the first condition, more commonly referred to as heteroscedasticity, is typically a concern in models which employ cross-sectional data as opposed to time-series data. Violation of the second condition, known as collinearity or ill-conditioning, occurs when two or more independent variables in the model are highly correlated. In either instance, when heteroscedasticity or collinearity is present, parameter estimates retain the qualities of unbiasedness and consistency, but loose efficiency. As a result, estimated variances of the parameter estimates will be biased, classical tests of significance will not be accurate, and confidence intervals will be incorrect. Consequently, from the standpoint of interpreting model results, it is important that the existence of heteroscedasticity and collinearity be tested, and if found to be present, remedial actions taken.

The presence or absence of heteroscedasticity in the expenditures model was tested through the use of the Park-

Glejser test (Park, 1966; Glejser, 1969). Following Park's suggestion, the natural logarithm of the squared regression residuals was regressed on the independent variables of the original model. On the basis of a test of the significance of the estimated parameters from this model, the null hypothesis of homoscedasticity could not be rejected. Consequently, no correction for heterscedasticity was warranted or undertaken. The presence of collinearity in the model of expenditures on "assessment information" items was explored through the use of variance inflation factors, condition indices and regression coefficient variance decomposition. In no instance was significant collinearity indicated and, as a result no further action was taken.

Inspection of the parameter estimates and t-ratios shown in Table 3.2 indicated that type of organization and the mission of the organization were not significant in explaining expenditures on "assessment information". However, division or branch annual operating budget was significant and positively related to expenditures. For every $100,000 increase in the respondent's agency's annual operating budget, an increase of approximately $23 on "assessment information" within the context of the contingent expenditure game would be forthcoming.

With respect to individual-specific characteristics, those with professional training in the area of public administration/business management would be expected to spend approximately $11,650 less than similar individuals with backgrounds in engineering or hydrology. The impact of professional training in the social sciences and physical/biological sciences on expenditures was not significantly different from that of training in engineering or hydrology.

Percentage of professional time spent in budget allocation/preparation activities had a significant negative effect on expenditures. For every 10 percent increase in professional time devoted to this general area of organizational responsibility, expenditures on "assessment information" would be expected to decrease by approximately $9,000. Percentage of time devoted to program planning responsibilities and percentage of time devoted to agency operation activities were not significantly related to expenditures. Additionally, years of professional involvement in water related issues was not found significant in determining the level of expenditures on "assessment information".

3.5 *SURVEY TWO*

As previously indicated, in order to adequately test the empirical models relating National Water Assessment use and expenditures made for "assessment information" to individual and organizational characteristics, a two-part survey approach was adopted. This two-part approach consisted of an initial survey and analysis conducted in one water basin management context, subsequently followed by a second survey and analysis in another setting with a different management issue. In addition to providing additional evidence upon which to judge the models, consideration of a second survey context also provided an opportunity to modify the survey instrument and/or the operationalization of the general model concepts pursuant to the experience gained through the first survey.

In determining what, if any, fundamental modifications would be made in the questionnaire and/or concept operationalizations for the second survey, consideration was given to questionnaire responses, response rates, respondent comments (Appendix C), and to the results of the analysis conducted for the Missouri River basin. Taken together, these factors indicated that, in general, the techniques and methods employed in the first survey had been successful. The high response rate of 75 percent, the quality of the responses, and the comments received from respondents all suggested that the questionnaire, and most especially the contingent elicitation questions, were understandable. Moreover, the letters of transmittal and scheduling of mailings was apparently sufficient to convince most of those contacted that their participation was important.

With respect to the hypothesized models of Assessment use and expenditures on "assessment information", in only one instance was it determined that a concept operationalization used in the Missouri River basin survey should be modified. Because of a number of "other" responses with respect to the agency mission question, and because of the nonsignificance of agency mission in the Missouri River basin expenditure model results, two of the mission categories employed in the first survey were partitioned. DVLPLN, representing a development or planning mission as defined in the initial survey, was partitioned into RESDVL indicating a natural resource development mission, and RESPLN indicating a natural resource planning mission. REGMGT, representing a regulatory or management mission as defined in the initial survey, was partitioned into ENVREG indicating an environmental regulatory mission, and RESMGT indicating a natural resource management mission. SCINV, representing a scientific-investigative agency mission was left unchanged. As a result, respondents of the second survey were presented five categories by which to indicate the mission of their agency. Consequently, the empirical models of National Water Assessment use and expenditures for "assessment information" for the second survey were modified to reflect this change. The modified model for use/nonuse of the second national water assessment was specified as:

$$\begin{aligned} USE = {} & B_0 + B_1\ FEDFLD + B_2\ STATEREG + B_3\ RESPLN + B_4\ ENVREG \\ & + B_5\ RESMGT + B_6\ SCINV + B_7\ BUDGET + B_8\ SOCSI \\ & + B_9\ PHYBIO + B_{10}\ PABM + B_{11}\ BUDP + B_{12}\ PPP \\ & + B_{13}\ AOP + B_{14} + \varepsilon \end{aligned}$$

Similarly, the modified model of hypothetical expenditures on "assessment information" was specified as:

$$\begin{aligned} EXPA = {} & B_0 + B_1\ FEDFLD + B_2\ STATEREG + B_3\ RESPLN + B_4\ ENVREG \\ & + B_5\ RESMGT + B_6\ SCINV + B_7\ BUDGET + B_8\ SOCSI \\ & + B_9\ PHYBIO + B_{10}\ PABM + B_{11}\ BUDP + B_{12}\ PPP \\ & + B_{13}\ AOP + B_{14} + \varepsilon \end{aligned}$$

For both models the following variable definitions applied:

RESDVL	1 if agency mission was natural resource development; 0 otherwise.
RESPLN	1 if agency mission was natural resource planning; 0 otherwise.

ENVREG	1 if agency mission was environmental regulation; 0 otherwise.
RESMGT	1 if agency mission was natural resource management; 0 otherwise.
SCINV	1 if agency mission was scientific-investigative; 0 otherwise.

All remaining variables were as previously defined. To avoid perfect collinearity among the agency mission variables, RESDVL was omitted from the empirical models and, consequently, the effects of the other agency mission categories are relative to RESDVL.

Because the similarity between the empirical models employed in the first survey and those proposed for the second, prior expectations regarding the relationships between the independent and respective dependent variables were maintained. Only in the case of the variables summarizing agency mission is further elaboration required. Consequently, the following sections deal only with the expected effects of agency mission, as defined for the second survey, upon the use of the Second National Water Assessment and expenditures made upon "assessment information".

3.5.1 *Agency Mission and National Assessment Use*

As indicated previously, the mission of an agency tends to condition the environment within which the water resource decision participant operates by narrowing the range of problem/issues he is likely to confront and by casting those problems in a form amenable to the agency's perception of what it can and should do. Consequently, the mission of an organization is expected to affect the probability that the individual would have used the Second National Water Assessment. As in the Missouri River basin survey, it was expected that individuals located within a developmental or planning agency would have the greatest probability of having used the assessment of the various mission categories. As before, this expectation is primarily based upon the presumption that the assessment does more to support the typical activities and interests of these agencies than those with differing missions. However, given the way in which mission was defined in the Chesapeake Bay drainage basin survey, it was expected those who were employed by resource planning agencies would have an even greater probability of having used the assessment than those located in resource development agencies. Consequently, RESPLN was expected to exhibit a positive change in the probability of using the Second National Assessment, as compared to the omitted RESDVL, while ENVREG, RESMGT, and SCINV were all expected to exhibit negative probability changes.

3.5.2 *Agency Mission and Expenditures on Assessment Information*

For the same reasons stated above, agency mission was expected to affect expenditures on "assessment information" in the same general manner as it affected the probability of national water assessment use. Therefore, in the Chesapeake Bay drainage basin context of low freshwater inflows, individuals employed by resource planning agencies were expected to spend more, and individuals employed by environmental regulatory, resource management, and scientific-investigative were expected to spend less relative to those located in resource development agencies.

3.5.3 *The Chesapeake Bay Drainage*

Located within the states of Virginia and Maryland, Chesapeake Bay is the nation's largest and most productive estuarine system. With a long history as a natural, economic, and social resource, Chesapeake Bay and its tributaries support a wide range of uses including navigation, recreation, municipal and industrial water supply, waste disposal, fish and wildlife habitat, and commercial fishing. The Bay's drainage basin, which includes most of Maryland

and Delaware as well as portions of Virginia, West Virginia, Pennsylvania, and New York (Figure 3.2), encompasses more than 64,000 square miles.

In terms of geological time, Chesapeake Bay is fairly young. It is generally thought that the Bay formed approximately 10,000 years ago at the end of the last ice age when glacial melting, and the resultant addition of freshwater to the oceans, inundated the ancient Susquehanna River valley. Today the Bay is approximately 200 miles long and varies from four to thirty miles in width. It has an average depth of 28 feet with two-thirds of the Bay at 18 feet or less. Approximately 150 rivers and creeks are drained by Chesapeake Bay. Of these, 50 are considered major water courses while a mere six contribute nearly 90 percent of the freshwater inflow to the Bay. These six rivers include the Susquehanna, the Potomac, the Rappahannock, the James, the York, and the Patuxent. "Together these six rivers shape the circulation and salinity regimes which govern the Chesapeake estuary. How land (and water) is managed within each of these basins largely determines the volume and chemical characteristics of freshwater discharged to the Bay (EPA, 1983, p. 3)."

Because of the varying degree of interaction between seawater and freshwater from riverine sources, the Bay

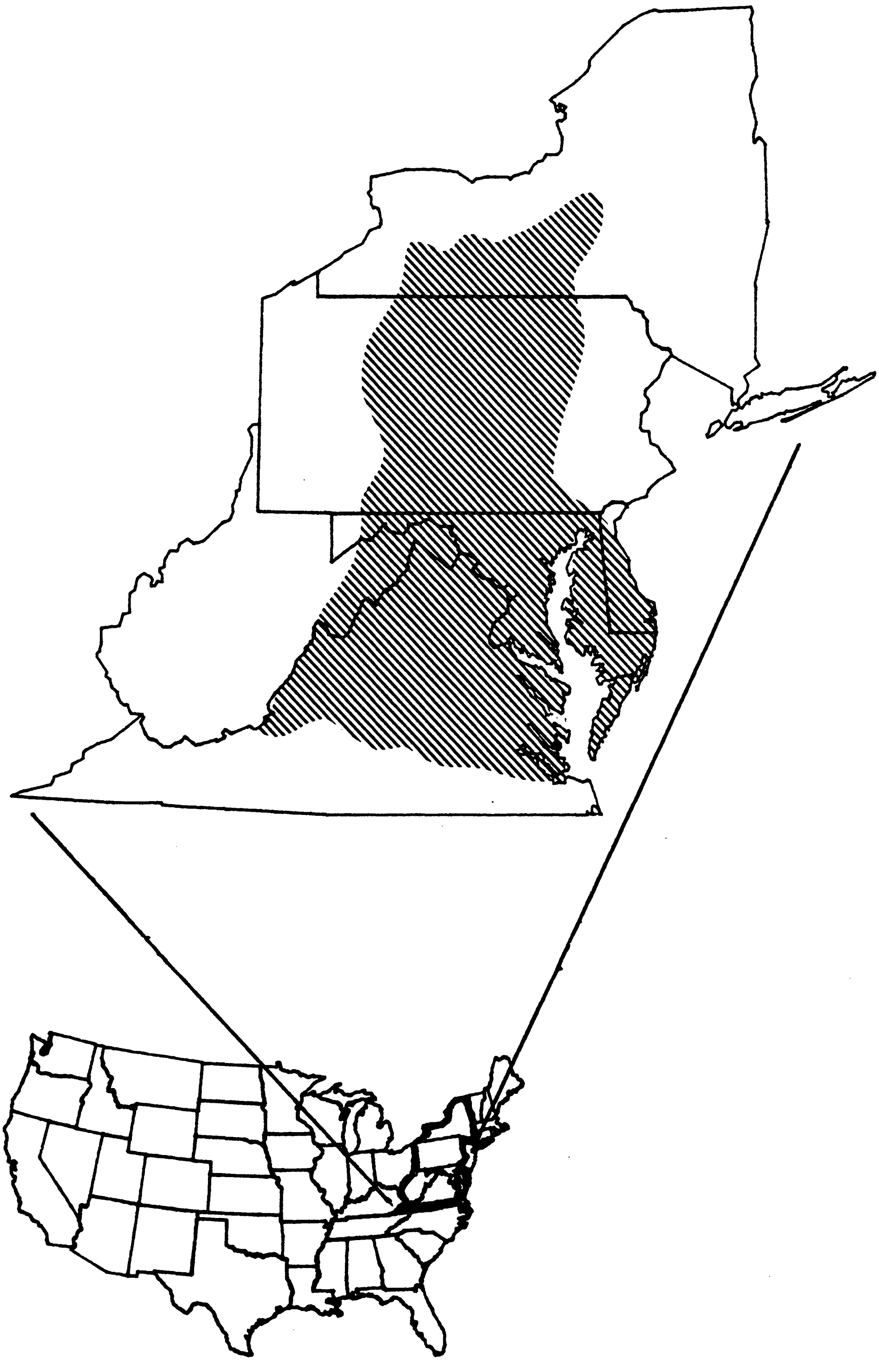

Figure 3.2: The Chesapeake Bay Drainage

provides a diversity of ecological conditions in which a multitude of aquatic organisms thrive. As a result a significant commercial fishing industry has long been present on Chesapeake Bay. Some of the more important commercial species found in the Bay include blue crabs, soft shelled crabs, and menhaden. Additionally, Chesapeake Bay oysters represent nearly 43 percent of the total U.S. domestic production.

Primarily because of its economic importance, Chesapeake Bay has been the subject of research for many years. In reviewing the accumulation of studies and reports, the U.S. Corps of Engineers (1984) concluded that the Bay was one of the most intensively investigated estuarine systems in the United States. In a four volume bibliography published in 1976 as part of the Coastal Zone Management program of the Maryland Department of Natural Resources and the Virginia Institute of Marine Sciences, approximately 7,400 previous reports related to Chesapeake Bay were cited. Prior to the 1960s and 1970s much of the research conducted on Chesapeake Bay was primarily descriptive. More recently, Bay related studies have evolved toward a coupling of monitoring and research directed to present and emerging problems. As a result of the interaction and involvement of numerous Federal, state, and regional organizations, a ". .

. regional management ethic (EPA, 1983, p. iii)" in the Chesapeake Bay drainage appears to have emerged. In correspondence with this "ethic", there is the sense that the many diverse responsibilities and interests are striving for similar goals. One indication of this has been the general commitment among the Federal, state and regional management organizations to a basin-wide data base. As a result of this basin identity and because of an institutional familiarity fostered by its close geographical proximity and other ongoing research, the Chesapeake Bay drainage basin was selected as the basin context within which the second portion of this study's two-part survey strategy was conducted.

Recently, studies conducted by the Environmental Protection Agency (1983) and the U.S. Army Corps of Engineers (1984) have identified several potential problems important to the Bay.[12] One of these is the effect that future decreases in freshwater inflows may have upon Chesapeake Bay water quality. As noted above, the interplay of seawater and freshwater inputs from riverine sources determines the ecological conditions which characterize Chesapeake Bay waters. Should the volume or quality of freshwater inflows to the Bay appreciably change, the distribution

[12] Among others, these issues have included tidal flooding, water pollution effects, and low freshwater inflows.

of environmental conditions found within the Bay would also be altered. Such a change in freshwater inflow has been forecast as a result of future increases in consumptive water use by municipalities, industries, and agricultural interests located adjacent to Chesapeake Bay tributaries. By altering the estuarine environment, primarily by increasing levels of salinity, declining freshwater inflows may adversely affect the Bay's aquatic life impacting commercial and recreational fishing, and may increase treatment costs for industries and municipalities which use the Bay as a water supply source. Potential corrective measures for this problem which might applied within the Bay include more intensive fisheries management, and oyster bed restoration. Potential corrective measures which could be implemented in the Bay's drainage basin include augmentation of inflow through the construction of upstream reservoirs and/or the reallocation of storage in existing reservoirs, interbasin importation of water, development of groundwater resources, implementation of basin water conservation programs, and adjustment of water pricing policies to control demand.

Because of the importance of the low inflow problem as evidenced by the U.S. Army Corps of Engineers report (1984), and because the low inflow issue was expected to be less of an emotional issue as compared to such issues as Bay pollution and tidal flooding, the low freshwater inflow problem was selected as the issue context of the survey of Chesapeake Bay water resource decision participants.

3.5.4 *The Survey*

As in the survey of Missouri River basin decision participants, data used in the empirical analyses of the second survey were obtained through a mailed questionnaire survey. Approximately 358 questionnaires were mailed to state, regional, and federal water resource decision makers having responsibilities in the Chesapeake Bay drainage basin. Of these questionnaires, 144 were sent to individuals identified as involved in water resources management while the remaining 114 were sent in groups of two to the directors of Federal, state and regional water management organizations. These directors were requested to direct both questionnaires to upper-level water resource decision makers within their agency. The Survey was conducted using the Total Design Method (Dillman, 1978) during the period of January 23 - March 9, 1986.

As in the initial survey conducted in the Missouri River basin, respondents could have been contacted by mail on three separate occasions (Appendix A). At the outset, a letter describing the purpose of the survey and requesting assistance, along with a copy of the questionnaire, was sent to each potential respondent. One week later, a postcard was mailed to each respondent reminding him of the survey and thanking him for his assistance. Finally, after the passing of a four week period, individuals who had not responded were sent a second letter and questionnaire requesting their assistance. Names and addresses were obtained from several sources included a listing of USGS State-Federal Cooperators located in the Chesapeake Bay drainage, the Federal Directory, and the mailing list used by the U.S. Environmental Protection Agency in its Chesapeake Bay Study (1983). Of the 358 questionnaires originally mailed, 182 were eventually returned resulting in a response rate of 51 percent.

Unlike the Missouri River basin survey, numerous inquiries were received from respondents at both the state and Federal levels. Common questions included the purpose of the survey and to whom it had been sent. In addition, it was discovered that many of the questionnaires were redirected from their intended recipient to other individuals with the same agency. In some instances, individuals in field offices felt compelled to redirect their questionnaire to colleagues in the headquarters office, while in other instances just the reverse was true. While provisions were made for redirection in the instructions which accompanied each questionnaire, the extent of redirection which occurred in the Chesapeake Bay survey as compared to that which occurred in the Missouri River basin was surprising. Of more concern was a tendency within some organizations (primarily Federal headquarters agencies) for questionnaires to gravitate toward specific departments. For example, a number of questionnaires were sent to a wide range of individuals within the Washington D.C. office of the Environmental Protection Agency. Several weeks after the initial mailing, the EPA's Office of Estuarine Protection received "numerous" questionnaires which had been redirected from others within the agency. In order to avoid biasing the sample, that office was requested to redistribute these questionnaires where possible and to disregard any remaining questionnaires except those which had originally been mailed to its personnel.

Of the 182 completed questionnaires returned, 30 were eliminated from the empirical analysis due to missing information. As a result, the analyses conducted for the Chesapeake Bay drainage were based upon the remaining 152 observations.

3.5.5 *The Questionniare*

As in the Missouri River basin survey, the instrument employed in the survey of Chesapeake Bay drainage basin water resource decision participants was composed of three principle sections. The first section, covering the first two pages (Appendix B), included questions which were again intended to spark the interest of the respondent and reinforce the message that his opinions were vital to the success of the study. To accomplish this, the respondent was queried as to his past use of and satisfaction with the Second National Water Assessment and his use of and priorities for a Chesapeake Bay data system.

The second section of the questionnaire presented the respondent with the two contingent elicitation situations employed in the previous survey. The first of these, a contingent ranking exercise, will be discussed in Chapter 4. In the contingent expenditure exercise, the respondent was for the second time asked to assume that his organization had made him responsible for analyzing the Chesapeake Bay low freshwater inflow problem and for making policy recommendations. Unlike the Missouri River basin survey, however, the respondent was provided with some basic water information prior to his participation. This included estimates of current flow rates for the five major Bay river systems, and current and future estimates of withdrawal and consumptive uses for these major river systems. This fairly aggregate level information was provided in an attempt to better assess the demand for "assessment information" at the margin since consideration of the results of the Missouri River basin survey indicated that most individuals require a minimum amount of "assessment information", regardless of their personal or organizational characteristics, just to establish and define the problem.

Again this backdrop, respondents were asked to assemble their most preferred information system from the list of 17 information items and associated costs subject to a $100,000 hypothetical budget. Among the list of items were "assessment information", some of which paralleling the provided "assessment information" but at a more detailed individual stream level, and various items of economic and biological information of potential value to the low freshwater inflow issue. As in the Missouri River basin survey, costs for the items of information were established in an effort to: 1) roughly represent the relative costs of the different types of information, and 2) to provide the respondent with balanced expenditure opportunities across "assessment" and "non-assessment" information. Based upon respondent selections, *marginal* expenditure made for "assessment information" was calculated and served as the dependent variable for the expenditure model of the second survey.

The remaining section of the questionnaire included questions designed to elicit personal and organizational characteristics hypothesized to influence information demand. As in the initial Missouri River basin survey, the final page of the questionnaire provided the respondent the opportunity to comment on the questionnaire, public water data collection priorities, or other insights or concerns. A listing of these comments is presented in Appendix C.

A presentation and discussion of simple statistics describing the Chesapeake Bay sample are presented in Appendix D.

3.5.6 *Results of National Water Assessment Model*

Results of the qualitative response model describing use of the Second National Water Assessment by water resource decision participants in the Chesapeake Bay drainage basin are presented in Table 3.3

For this analysis the logit model required five iterations to generate the estimated parameter coefficients at a convergence tolerance of 0.001. Consideration of the summary statistics presented at the bottom of the Table 3.3 shows an empirical R^2 equaling 0.2688 which is somewhat

TABLE 3.3

Maximum Likelihood Estimates for Assessment Use Model - Chesapeake Bay Drainage

VARIABLE	ESTIMATE	CHANGE IN PROB[a]	T-RATIO
INTERCEPT	-1.7975		-1.291
FEDFLD	-.26764	-.0284742	-.44033
STATEREG	-1.2435	-.1322960	-2.0283
RESPLN	1.8195	.1935766	1.7563
ENVREG	-1.3704	-.1457969	-1.0084
RESMGT	1.195	.1271361	1.243
SCINV	.39148	.0416496	.37997
BUDGET	-.0002037	-.0000217	-.99612
SOCSI	-.6283	-.0668448	-.6214
PHYBIO	-1.0116	-.1076241	-1.962
PABM	-.8173	-.0869525	-.6436
BUDP	.02519	.0026800	.77013
PPP	.00239	.0002543	.1695
AOP	-.01348	-.0014341	-1.2169
ACTIVE	.07588	.0080729	2.4901

[a] Computed at Sample Means

Log of Likelihood function = -58.666 in 5 iterations.
R-Square = .2688
Upper Bound on R-Square Assuming Beta Distribution = .2442
Ratio of R-Square to Upper Bound = 1.10
Efron's R-Square = .2678
McFadden's R-Square = .2369
Likelihood Ratio Test = 36.44 with 14 degrees of freedom.
82.9 percent respondents correctly classified.
Probability of Use at Sample Means = 12.1 percent.

larger than the comparable R^2 obtained in the Missouri River basin survey. Comparing this to the calculated upper bound on R^2 of 0.2442, assuming a beta distribution for the predicted probabilities (Morrison, 1972), reveals that in this case empirical R^2 exceeds the upper bound. While this at first might appear perplexing, such an occurrence is not uncommon and may merely indicate that a beta distributional assumption in this case may not be satisfactory. Efron's R¬2¬ equaled 0.2678 while McFadden's R¬2¬ was slightly less at 0.2369. With a likelihood ratio test of 36.44 with 14 degrees of freedom, the null hypothesis of nonsignificance of the model was rejected. As in the corresponding model for the Missouri River basin, information concerning the predictive ability of the model was investigated using a 50:50 classification scheme. Approximately 83 percent of the respondents were correctly classified by the model as to their use or non-use of the Second National Water Assessment. Here, the probability of an individual using the Second National Assessment at the sample means was calculated to be only a little more than 12 percent.

As in the results of the Missouri River basin assessment use model, inspection of parameter estimates and probabilities generally confirms previously held expectations where significance existed. Moreover, the same pattern of variable group significance revealed in the prior survey was again realized. Only agency budget, and professional responsibility as represented by the variable group BUDP, PPP, and AOP, did not significantly affect the probability of Second National Water Assessment use.

As expected the logit analysis indicated that an individual employed by a state or regional water resource organization was significantly less likely to have used the Second National Assessment as compared to a similar individual employed by a Federal headquarters organization. Other things being equal, state/regional water resource decision participants were shown to be 13 percent less likely to have used the water assessment. The probability of assessment use by individuals employed by a Federal field organization was not significantly different from that of individuals located in Federal headquarters agencies.

The logit analysis further indicated that an individual employed by an organization with a resource planning mission had a significantly higher probability of assessment use relative to an individual located within a natural resource development agency. Consistent with theoretical expectations, employment by an organization with a resource planning mission increased the probability of assessment use by approximately 19 percent.

With regard to personal characteristics of the water resource decision participant, as in the prior survey, an increase in years of professional activity in water resource issues had a significant and positive effect on the probability of Second National Water Assessment use. As expected, the change-in-probability associated with ACTIVE indicated that increasing experience in water resource issues by one year, *ceteris paribus*, resulted in a 7.6 percent increase in the probability of assessment use.

The change in probability associated with PHYBIO indicated that an individual with professional training in the physical or biological sciences was 11 percent less likely to have used the assessment than a similar individual with training in engineering or hydrology. This finding was contrary to that which was expected. Professional training in the social sciences and the physical/biological sciences had no significant effect on the probability of assessment use relative to a background in engineering or hydrology.

3.5.7 *Results of Expenditures for Assessment Information Model*

Results of the ordinary least squares estimation of Chesapeake Bay water resource decision participant expenditure on "assessment information" are displayed in Table 3.4

TABLE 3.4

OLS Estimates of Expenditure Model - Chesapeake Bay Drainage

VARIABLE	ESTIMATE	T-RATIO
INTERCEPT	3.043000	2.307
FEDFLD	-0.275516	-0.420
STATEREG	0.382138	0.695
RESPLN	-0.326433	-0.316
ENVREG	-1.082316	-1.192
RESMGT	-2.407239	-2.777
SCINV	-0.474711	-0.491
BUDGET	0.000085997	0.626
SOCSI	-0.114104	-0.109
PHYBIO	0.380401	0.721
PABM	-0.993173	-1.067
BUDP	0.085234	2.577
PPP	0.032065	2.177
AOP	0.023827	2.332
ACTIVE	-0.009492	-0.339

F-Value = 2.020
R-Square = .1711
Collinearity Diagnostics Negative.
Heteroskedasticity Diagnostics Negative.

As the summary statistics indicate, the F-value for this model of 2.020 allowed rejection of the hypothesis that all slope coefficients for the model were equal to zero. Accordingly, the amount of variation explained by the model was significant. R^2 for the model was .1711, implying that approximately 17 percent of the total variation in expenditures was explained by the model. While this R^2 is less than that obtained for the results of the Missouri River basin expenditure model, it must be remembered that in studies employing cross-sectional data an R^2 of .20 is normally considered satisfactory. Since .17 is fairly close to .20, the results of this regression can be regarded as acceptable, although a larger coefficient of determination would have been desirable.

As in the previous survey, the presence or absence of heteroscedasticity in the expenditures model was tested through the use of the Park-Glejser test (Park, 1966; Glejser, 1969). This involved regressing the independent variables of the original model on the natural logarithm of the squared regression residuals. Following a test of the significance of the estimated parameters from this model, the null hypothesis of homoscedasticity was not be rejected. The presence of collinearity in the model of expenditures on "assessment information" items was explored through the use of variance inflation factors, condition indices and regression coefficient variance decomposition. In no instance was significant collinearity indicated and, as a result no further action was taken.

Inspection of the parameter estimates and t-ratios shown in Table 3.4 indicated that type of organization and division or branch annual operating budget were not significant in explaining expenditures on "assessment information". However, employment by an organization with a resource management had a significant and negative effect on expenditures. Employment by a natural resource management organization decreased an individual's expenditures on "assessment information" by a little more than $24,000 as compared to a similar individual located in a resource development agency.

With respect to individual-specific characteristics, neither professional training nor years of experience in water related issues explained a significant amount of variation in expenditures. However, in this instance, the three continuous variables summarizing the individual's distribution responsibilities, BUDP, PPP and AOP, all proved to have a significant and positive effect on "assessment information expenditures. Respectively, a 10 percent increase in the amount of professional time devoted to budget allocation/ preparation, program planning, and agency operations increased expenditures on "assessment information" by $8,500, $3,200, and $2,400.

3.6 *SUMMARY OF RESULTS*

Results of the foregoing analyses support the general hypothesis that organizational characteristics, as well as personal characteristics of the individual, influence water resource decision participant demand for water resources information. Even when confronted with identical water management issues and identical informational possibilities, different individuals exhibit different information priorities. For those explanatory variables which were observed to be statistically significant, *a priori* expectations regarding effects on National Water Assessment use and expenditures on "assessment information" were confirmed. In only one instance did a significant explanatory variable exhibit a sign different from the one hypothesized. The parameter estimate associated with PHYBIO in the Chesapeake Bay Assessment use analysis was hypothesized to be positive since individuals with physical or biological science training were expected to have a greater likelihood of having used the assessment than those with training in engineering or hydrology. Despite this expectation, a negative relationship was observed. While the results of both models

(National Water Assessment Use and expenditures on "assessment information) contribute to the general acceptance of the hypothesis that organizational environments influence information demand, the results exhibited by the logit analyses of assessment use by Missouri River basin and Chesapeake Bay drainage water resource decision participants are the most convincing.

For the analysis of National Water Assessment use or nonuse, both the Missouri River basin survey and the Chesapeake Bay drainage survey offered good model results. In both analyses, the extent to which the logit model was able to explain variation in the dependent variable was high as evidenced by comparison of the R^2 measures to the upper bounds on R^2 assuming the predicted probabilities followed a Beta distribution. Additionally, from the standpoint of ability to predict use or nonuse of the Assessment by water resource decision participants, both analyses indicated that the model was quite successful with a 73 percent correct classification rate for Missouri River basin respondents and an 83 percent correct classification rate for Chesapeake Bay drainage respondents. In both analyses, the logit model identified significant differences in the probability of Assessment use within each of the organizational and personal characteristic categories except for division or branch budget and organizational responsibilities as represented by BUDP, PPP, and AOP. Despite the expectation that larger division budgets, *ceteris paribus*, should allow the acquisition of more specific information than that provided by the National Water Assessment, thus reducing the decision participant's probability of Assessment use, probability of use is invariant to division budget. One explanation for this observation is that the National Water Assessment has essentially been a free good to water resource decision participants as well as to the public at large. Since use of the Assessment imparts no price penalty to the division's budget, water resource decision participants are free to use the Assessment as well as other more specific information which may be acquired by their immediate organization. Accordingly, size of budget is not an issue in probability of National Assessment use. Lack of significance in the organizational responsibility variables was likely due to unsatisfactory operationalization of this concept. As discussed previously, selecting an appropriate and measurable operationalization for describing the decision participant's responsibilities within the organization proved to be somewhat of a problem. Percentage of professional time devoted to a small number of activities was selected as one way of representing the nature of the individual's tasks and responsibilities which result from the position he occupies in the organization. While BUDP, PPP, and AOP all proved to be insignificant in both assessment use analyses, organization theory would suggest that the nature of the individual's organizational responsibilities should play a major role in the types of information he demands.

Unlike the results of the Assessment use analyses, the results obtained from analysis of expenditure behavior for the Missouri River basin survey and the Chesapeake Bay drainage survey were somewhat contradictory. While the Missouri River basin analysis provided good results, the results observed for the similar analysis based on Chesapeake Bay decision participant responses were disappointing. The coefficient of determination for the Missouri River basin analysis (0.26) indicated that the model explained an acceptable amount of variation in the observations, taking into consideration that they were cross-sectional individual responses. Of the six organizational and personal characteristic categories, the Missouri River basin analysis identified significant differences leading to different expenditure behavior in three. In the characteristic category expected to have the greatest effect on "assessment information" expenditures, disciplinary training/background, all variables had the expected signs. However, only those individuals with training in public administration or business management had significantly different expenditure levels as compared with those with hydrology or engineering backgrounds. For the Chesapeake Bay drainage analysis, however, R^2 was much less, indicating that only 17 percent of the total variation in expenditures for "assessment information" was explained by the model. This was despite the fact that because the three qualitative variables representing agency mission employed in the Missouri River basin analysis were partitioned into five qualitative variables, the Chesapeake Bay expenditure model contained two additional explanatory variables. In general when more variables are added to a model, the value of R^2 is observed to increase. Additionally, the Chesapeake Bay drainage "assessment information" expenditure analysis detected significant differences in expenditure levels in only two of the six organizational and personal characteristic categories.

In one sense, the results from the two expenditure analyses are not directly comparable since, in the Chesapeake Bay drainage survey, expenditures made by respondents were for marginal additions of "assessment information" to a previously existing information base. In the Missouri River basin survey no prior water resource information was provided to the respondent. Consequently EXPA in the Chesapeake Bay analysis was interpreted as total expenditures for "assessment information". However, the same general factors which influence total expenditures should influence marginal expenditures in a similar fashion. This fact makes interpretation of the parameter estimates associated with BUDP, PPP, and AOP difficult. For the Chesapeake Bay expenditure analysis, all three of these parameter estimates were observed to be significant and positive. While no particular relationship was hypothesized between these variables and expenditure, they would not be expected to carry equivalent signs. Budget preparation and agency operations both represent one primary organizational responsibility type ("doing"), while future program planning represents a different type of organizational activity ("thinking"). To the extent that these two general types of activities compete for the same limited amount of professional time, it would be expected that the parameter estimate associated with PPP would be signed differently from those associated with BUDP and AOP.

In considering the relative success of the assessment use analyses as compared to the "assessment information" expenditure analyses, and the better performance of the Missouri River basin expenditure analysis relative to the Chesapeake Bay expenditure analysis, two interrelated contributing factors are clear. First, while the two water resource decision participant populations were similar in terms of age, education, etc., they must be regarded as quite distinct with respect to their level of sophistication in considering water resource issues and water resource information. This fact, coupled with the hypothetical nature of the "assessment information" expenditure situation posed in the questionnaire accounts for why Assessment use/ nonuse results are better than the expenditure model results and why expenditure results in the Missouri River basin are superior to those observed in the Chesapeake Bay drainage. Water resource decision participants located in the Missouri River basin have a long history of dealing with water resource scarcity and the conflicts generated by scarcity. This experience has provided individuals charged with water resource management in the Missouri River basin with an appreciation of the different types of water information available to them and the relative value of that information in the organizational decision process. In contrast, water problems in the relatively "well-watered" East have only been perceived fairly recently, particularly when related to problems over water quantity. Compared to counterparts in the Missouri River basin, individuals responsible for water management in the Chesapeake Bay drainage area are less sophisticated in terms of assessing the relative benefits of different type of water resource information. This became quite evident during the period following the inital survey mailing to the Chesapeake Bay sample group. For the Assessment use/nonuse analysis, water resource decision participants were requested only to indicate whether they had or had not previously used the Second National Water Assessment. The definition of what constituted "use" was left up to the discretion of the respondent. Because the question was based on unambiguous past behavior, little room for confusion on the part of the respondent existed, resulting in accurate responses and successful model results. For the "assessment information" expenditure analysis however, responses were based not on unambiguous prior behavior, but upon expectations of how one would behave if the hypothetical situation posed were to occur. Because of the greater degree of sophistication of the Missouri River basin respondents, the hypothetical nature of the situation apparently provided few problems. As previously reported the Missouri River basin survey resulted in a high response rate of 75 percent. In addition few questions and no complaints regarding the survey were received. For the Chesapeake Bay drainage survey, though, quite the opposite was true. In comparison to the Missouri River basin response rate of 75 percent, a much lower response rate of 51 percent was realized for the Chesapeake Bay drainage. Numerous questions from respondents were received reflecting suspicion over the "true" motives of the survey and questioning its confidentiality. Some individuals commented that the low freshwater inflow issue was not a problem worth considering. In the "assessment information" expenditure situation, a proportion of the survey respondents failed to allocate most or all of their budget endowment even though feasible (in terms of cost) information items remained. Since the hypothetical situation provided no alternative uses for remaining funds, failure to allocate as much of the budget as possible to water information items served no purpose. The existence of this observed behavior indicates that those individuals may not have completely understood the situation or did not care to exert the mental effort required to fully complete the question. In addition, as reported earlier, large numbers of questionnaires were passed from the intended recipient to other individual's within the organization. This was especially true in the Federal water management agencies where as many as 17 questionnaires were forwarded to one individual. One result of this was that many questionnaires were simply discarded. More importantly though, these considerations raise the possibility that some proportion of the questionnaires received do not reflect the considered responses and opinions of Chesapeake Bay water resource decision participants, but reflect an attempt to merely comply with the letter but not the spirit of the investigator's request. For these reasons the results of the the assessment use analyses were observed to support the general information choice model to a greater extent than the results of the expenditure analyses, and the expenditure analysis for Missouri River basin respondents produced more plausible results than the Chesapeake Bay drainage expenditure analysis.

Chapter IV

INFORMATION VALUATION THROUGH CONTINGENT RANKINGS

4.1 *PURPOSE AND CONTENT*

The purpose of this chapter is to report the results of a valuation method based upon contingent rankings as applied to water resource information items in the two river basin management survey contexts. The chapter begins with a discussion of nonmarket goods and the motivation, history, and techniques of nonmarket valuation which have most recently led to the development and use of the contingent ranking technique. Next, random utility theory, which provides the economic behavioral basis for contingent rankings, is discussed. This is followed by a presentation and discussion of the few prior instances in which the contingent ranking technique has been applied. Subsequent to that discussion, the empirical models and estimation technique used in this portion of the study are presented, as well as the results of contingent rankings for the Missouri River Basin and the Chesapeake Bay Drainage surveys. Based upon these results, marginal information item values are next calculated.

4.2 *NONMARKET VALUATION*

Since the late 1950s, economists have devoted substantial effort in devising economically consistent methods for estimating the monetary value of nonmarket goods and services. Attempts to value nonmarket goods and services are undertaken, presumably, to improve resource allocation decisions by including nonmarket benefits and costs on an equal footing with more conventional benefits and costs. Conventional practice defines nonmarket goods and services as those for which no well defined and observable market exists. In a broader sense however, the concept of nonmarket goods and services extends as well to those commodities for which a direct or indirect market does exist, but because of significant market imperfections the observed price cannot be taken as a true market clearing price.[13] Regardless of the category in which a particular nonmarket good might fall, the main significance of the above conditions is that they result in the absence of a market derived price which might be used in placing a value upon the provision of the good in question. Examples of

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[13] The classic example of the latter is outdoor recreation. Often entrance fees are charged of recreationists for use of state and national parks and recreational areas. In most cases however these fees are largely tokens, helping to defray some variable costs of park operation, but not approaching the entrance fees which would exist in a competitive market for outdoor recreation.

nonmarket goods and services are numerous including clean air, scenic vistas, environmental waste reception, and of course, public water resource information. While recent nonmarket valuation efforts have begun to consider a larger range of commodities, for the majority of the past two decades nonmarket valuation has been largely synonymous with the valuation of outdoor recreation.

The desire to place values upon recreational resources, which has ultimately led to more general nonmarket valuation efforts, is for the most part a fairly recent phenomenon. Prior to the 1950s very little empirical work had been done in the area of recreational demand and value estimation. According to Barkley (1968), as stated in his survey of the development of this type of analysis, "Early writers (1920s) did little more than isolate problems of allocation, impact, and institutions associated with recreational activity in a capitalistic, market oriented economy. Later writers (1930s and 1940s) began to give empirical content to their efforts but were entirely restricted to description. Recommendations are notably absent; the use of theory extremely primitive". Trice and Wood point out that as recently as 1958, the U.S. Forest Service refused to place dollar values upon forest recreation because of its "belief that even the most optimistic estimates will understate true recreational values, thus leading to disparagement as compared with non-recreational values (1958, p. 198)." Notwithstanding the tremendous advances in valuation methods since that time, some individuals and groups remain generally opposed to efforts designed to place values upon recreation and other nonmarket goods. Two predominant reasons can be offered to account for this opposition. First, individuals with a large vested interest in a given allocation of resources may oppose nonmarket valuation efforts since the valuation of previously unvalued goods or services may show that the current allocation is inefficient. If they believe that this might be the case, and that corrective actions might be implemented, they will oppose such efforts in favor of the status quo. Second, many opponents of nonmarket valuation argue that recreation, as well as other nonmarket goods and services, are fundamentally intangible, personal and varied. As such, they contend that it is simply impossible to determine values for this class of goods. To attempt to do so, they argue, would be as misdirected as trying to place a value on a mother's love for her child. Clearly, this argument is lacking since numerous goods and services such as education and entertainment are fundamentally intangible but nonetheless are continually allocated through market exchange.

Despite the Forest Service's attitude concerning nonmarket valuation, other Federal agencies including the National Park Service and the Army Corps of Engineers as early as the late 1940s expressed interest in methods to place values upon recreation. This interest was sparked from the desire to include the value of additional recreation in the more traditional development purposes of navigation, flood control, irrigation, and power production. As the demand and value for outdoor recreation (especially water-based recreation) was increasing significantly due to increases in real family income, mobility, leisure time, and degree of urbanization, the Federal development agencies saw the addition of recreational benefits as one way to gain greater project approval. Consequently, several early recreation valuation methods emerged. However, from an economic standpoint, each of these early methods were seriously flawed, suffering from either their fundamentally arbitrary nature or because of their circularity of reasoning.

Prompted by the deficiencies of these approaches, economists in the late 1950s and early 1960s began to suggest methods through which estimates of recreational value could be obtained which were consistent with economic theory (methods based upon individual's willingness to pay).

As a result of these suggestions, two principle techniques developed; the travel cost method, and contingent valuation. The travel cost method, has been characterized as an indirect method of nonmarket valuation in that it employs cost and use data obtained from user surveys to indirectly estimate demand and value. Contingent valuation, on the other hand, has been characterized as a direct method since individual willingness-to-pay estimates are elicited directly through the use of a hypothetical market.

4.2.1 *The Travel Cost Method*

The origins of the travel cost method can be traced to the publication of two seminal works by Trice and Wood in 1958 and by Clawson in 1959. However, both of these articles borrowed heavily upon an idea first expressed by University of North Carolina economist Harold Hotelling (1947). According to Trice and Wood, "Professor Hotelling suggested that a study be made of distances traveled by those using the national parks to determine the cost of such travel and, by comparing costs incurred by those travelling the greatest distances, to determine the dollar saving of all those able to enjoy the parks without incurring the full travel expense of the most distant travellers (National Park Service Prewitt Report, 1947, p. 198)". The Clawson article reiterated and expanded upon the basic approach suggested one year earlier by Trice and Wood. Clawson's essential contribution was to provide a theoretical foundation for the development of such analysis. Currently, no single travel cost approach exists. More accurately, the travel cost method has evolved into a collection of varying procedures differing from one author to the next. However these procedures do share one fundamental tenet. As stated by Freeman (1979),

> "... people spend time and money traveling to recreational sites, and these expenditures to use the site can be treated, with proper interpretation as a price for the site".

This quote reflects the fundamental idea which underlies the travel cost approach. The essence of this idea is to relate the nonmarket good or service to be valued with the joint consumption of a good or service which is traded in organized markets. In the case of outdoor recreation this has typically been the costs of transportation involved in reaching a recreational site. If the travel cost method were to be applied to other nonmarket goods and services, other jointly marketed commodities would have to be identified. Chavas and Pope (1985), for example, have suggested that the travel costs technique might be beneficially applied to the valuation of information. In this case a likely joint marketed good or service might be managerial time associated with information assimilation.

According to Clawson,

> It is both theoretically possible and practically manageable to put monetary values on outdoor recreation. The conceptual and theoretical problems, while somewhat novel, are not insurmountable nor perhaps unusually difficult; the problem of getting accurate and dependable data is serious but still manageable. (1959, p. 4)

The basic premise of the Clawson article was that while recreation has no readily observable market price, this does not imply that recreating activities are costless. Users do have to pay a "price" to engage in outdoor recreation. This is in the form of travel costs, token entrance fees, etc. Since travel cost comprises a large proportion of the total cost of recreation, with proper interpretation it may serve as a satisfactory proxy for price. Obviously users who live closer to a particular site will incur less costs to reach that site than do users who live at greater distances. As a result, one would further suspect that individuals with lower costs of transportation would also demand relatively larger amounts of recreation. In this way, persons living closer to a particular site gain a type of "surplus benefit". The summation of all these "surplus benefits" could be taken as a measure of the value of the recreational site.

Using data from observations of recreationists to a particular site, a demand curve for the recreational site can be statistically estimated. Using the information supplied by the estimated demand curve for the site, two primary monetary measures of recreational value have typically been calculated. The first of these is the Marshallian consumer's surplus,[14] while the second is the maximum revenue a nondiscriminating monopolist could generate from the site.

Since its introduction in the late 1960s, numerous refinements and modifications have been made to the original travel cost method. These improvements, which have predominantly sought to overcome many of the theoretical problems existing in the Hotelling-Clawson approach, have come to be incorporated through the incremental efforts of numerous authors. To a large extent, many of these modifications have focused on improving the specification of the recreational demand relationship. While these improvements and refinements have clearly increased the reliability and theoretical acceptability of the travel cost method during the past 25 years, several areas of continuing concern persist. Chief among these concerns is the appropriate treatment of travel time in the demand for recreation, and

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[14] While the Marshallian consumer's surplus is the concept of economic value most often calculated in nonmarket valuation studies, the more theoretically correct concept is the Hicksian income compensated measures of equivalent and compensating variation. But as demonstrated by Willig (1975), if nonmarket benefits are but a small proportion of total income and/or income elasticity is low, the degree of error incurred by using non-income compensated consumer's surplus will be small.

the problems generated by multiple destinations. As of yet, no satisfactory solution for either of these two problems has been proposed.

4.2.2 *Contingent Valuation*

Probably to an even greater extent than is the case for the travel cost method, numerous differing techniques exist under the general classification of contingent valuation.[15] However, quite in contrast to the approach taken in travel cost analyses, contingent valuation seeks to value nonmarket goods and services by directly eliciting willingness-to-pay or willingness-to-sell estimates from individuals. As Randall (1981) explains;

> The various techniques of contingent valuation all involve a process wherein the researcher creates a hypothetical market in a nonmarket good, invites a group of subjects (survey respondents or experimental subjects) to operate in that market, and records the results. The values generated through the use of the hypothetical market are treated as estimates of the value of the nonmarket good, *contingent upon* the existence of the hypothetical market. (p. 304)

At its most fundamental level, all contingent valuation approaches assume that: (1) individuals are capable of assigning *accurate* values to nonmarket goods under hypotheti-

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[15] Only during the late 1970s did this general approach to nonmarket valuation come to be known as contingent valuation. Prior to this it was referred to in a number of ways including the Davis method, the direct method, the survey method, and hypothetical valuation.

cal situations and, (2) the investigator is capable of eliciting these values with a properly constructed question or series of questions. Concern regarding either one or both of these assumptions is sufficient to cast doubt upon the validity of contingent valuation results. Recently Bishop and Heberlein (1979), in reviewing some work in the social psychology literature suggest that cause for doubt over these assumptions may indeed exist. According to them,

> In a review published in 1976 of 150 such studies, Schuman and Johnson (p. 168) concluded that the correlations between attitudes and actual behavior are usually so low that they will not "...support the *substitution* of measured attitude for behavior..." In other words, it may not be safe to assume, as economists applying hypothetical valuation techniques do, that what people say is what they would actually do.

While the use of contingent valuation was first introduced by Davis in 1963 only four years after the appearance of the Clawson article, little interest was afforded this approach until the middle to late 1970s. Much of this lack of interest can be traced to the head-start enjoyed by the travel cost method and to the eagerness of researchers to implement this new technique. More importantly though, many investigators tended to dismiss contingent valuation as an inferior method because of the incentives it might provide for individuals to respond in a strategic fashion. For example, if an individual believed that his response would result in greater provision of the nonmarket good, but that his costs would remain unchanged, he might overstate his true willingness-to-pay. If, on the other hand, the individual believed (correctly or incorrectly) that his answers might result in increased personal costs (increase in a user fee), he might respond by understating his true willingness-to-pay. However, as the decade of the 1970s arrived, problems affecting the validity of travel cost method results became increasingly obvious and, consequently, many of the previously held attitudes concerning contingent valuation began to be examined. In 1975 Dwyer, Kelly and Bowes noted that "despite a preference by many if not most economists to place more faith in information revealed by what people do rather than what they say, the survey method is useful (p. 75)." Additionally, because of its greater flexibility in defining the nonmarket good to be valued (strictly considered, the travel cost method is only applicable to situations involving outdoor recreation), contingent valuation was seen as potentially useful in providing information relevant to the expanding concerns over environmental services and amenities. At present, it could be argued that most economists regard contingent valuation as equal or superior to the travel cost method in most types of nonmarket valuation.

In any contingent valuation study, the quality of the results will largely depend upon how well the investigator "frames the question". For reliable results, it is essential that the hypothetical market be understandable and credible. In what psychologists refer to as "setting the context", the interviewer must effectively place the respondent in a realistic decision framework that stimulates a thought pattern which approximates the market process. This includes rigorously defining the commodity to be valued and the question format in a way familiar to the subject, specifying how the exchange would occur and the vehicle of payment, and describing other structural elements of the hypothetical market. As an example, if the investigator is interested in the value of deer hunting, he must carefully specify whether the good (or bad as the case may be) is the loss of one season of deer hunting, or the loss of deer hunting entirely. In addition he must specify in what manner the individuals monetary offer would be collected (increase in deer hunting license fees, increase in taxes on firearms and ammunition, etc), and the penalties for unauthorized hunting. Consequently, contingent valuation places much greater demands upon the personal skills of the interviewer than does the travel cost method.

As previously mentioned, the first application of the contingent valuation approach took place in 1963. In a Harvard University Ph.D. dissertation, Robert K. Davis surveyed a cross section of recreationists in and around Maine's Baxter State Park. In this study, Davis estimated individual willingness-to-pay for a park visit based upon income, length of visit in days, and years of acquaintance with the area. Using this estimated relationship in conjunction with estimates of total yearly visitation and the distribution of income, experience, and length of visit within the user population, total net willingness-to-pay for the park was calculated.

With the exception of new formats aimed at reducing potential biases, contingent valuation studies of the 1980s are not fundamentally different from those undertaken by Davis in the early 1960s. However, numerous variations on his elicitation approach have been suggested by subsequent authors. In general these approaches can be broken down into two broad groups: (1) techniques based upon some form of direct question and, (2) those based upon a process of iterative bidding.

Direct question techniques, as the name implies, entail a straightforward query of the respondent as to his valuation of the good in question after it has been unambiguously defined and the hypothetical market context established. Such questions may be open-ended or close-ended. Open-ended questions in essence ask the individual to express his maximum willingness-to-pay or minimum willingness-to-sell as the case may be. Close-ended direct questions, alternatively, require that the respondent only state whether or not he would be willing to pay or willing to accept some amount arbitrarily selected by the interviewer. Consequently, close-ended questions are not likely to disclose the individual's full valuation of the nonmarket commodity.

While in theory, open-ended questions are better equipped to permit the discovery of an individual's full willingness-to-pay, in practice such questions place the respondent in a totally unfamiliar situation. Normally, when an individual contemplates a purchase, he canvasses the market to find the lowest price for the good which he desires. If this price is greater than his subjective willingness-to-pay at that point, the purchase is foregone. If, on the other hand, the price is less than or equal to his willingness-to-pay, an exchange will normally take place. The format of the open-ended question turns this decision process on it head. Rarely does the consumer find himself in the position of having to examine his maximum willingness-to-pay in the absence of any initial price information. In an attempt to ameliorate this problem, investigators employing the open-ended direct question technique have frequently adopted the use of supporting devices such as bid cards. Arranged on these cards are dollar amounts of varying magnitudes. As the open-ended question is asked, the bid card is presented to the respondent. It is believed that the use of such devices may assist the respondent in selecting an amount approximating his full willingness-to-pay.

Because of their relative simplicity, direct question techniques are capable of being self-administered. As such, they have found favor among many investigators since they may be utilized in relatively low cost mail surveys. However, the reliability of results based upon this technique is open to some question.

The second major category of contingent valuation techniques is iterative bidding. Simply defined, iterative bidding techniques are close-ended direct questions which are successively repeated with varying amounts until an individual's maximum willingness-to-pay or minimum willingness-to-accept is discovered. For example, an individual might be asked if he would be willing to pay an additional $X in access fees to a particular lake if its water quality were improved from a boatable condition to a condition suitable for swimming. If the respondent answered affirmatively, the question would be repeated with larger amounts until a negative answer was observed. Similarly, if the answer to the initial question was negative, the process would be repeated with successively smaller amounts until an affirmative answer was recorded. In this way, an individual's full valuation of the nonmarket commodity is revealed. In a few rare cases though, a negative response to the initial question may not simply be a result of a lower willingness-to-pay, but due to the individual's refusal to participate in the valuation exercise based upon principle or because of his dislike of the vehicle of payment. Traditional practice in these cases has been to eliminate such observations from the data set. However it is not clear that this solution is appropriate from a theoretical standpoint since such individuals may indeed hold the particular nonmarket good in extremely high value.

While iterative bidding techniques are generally considered to be superior to direct question approaches, their iterative aspect necessitates the interaction existing only within the personal interview. Accordingly, the data gathering costs associated with this technique would be expected to be significantly larger than for studies employing direct questions.

Because of its inherently hypothetical nature, a good deal of concern has been focused upon various factors which may cause contingent valuation estimates to be biased. In fact, as previously discussed, much of the early disinterest in contingent valuation methods resulted from the *a priori* conclusions of many that "gaming behavior" on the part of respondents would invalidate survey results. More recently however, efforts have been directed toward identifying potential biases and testing for their presence in contingent valuation studies.

Bias, as it is discussed in the contingent valuation literature, is said to occur when an *individual's* stated valuation for a nonmarket commodity diverges from his "true" valuation. This "true" valuation is that which would have been held if the hypothetical market for the good in question had actually existed. Such biases may occur if either one or both of the main assumptions presented earlier are violated; specifically, if under the circumstances the individual is incapable of assigning accurate values to the nonmarket good (hypothetical bias), or the investigator is incapable of eliciting true values from the individual (strategic bias, payment vehicle bias, starting point bias, information bias). As such, the presence of bias in contingent valuation efforts does not necessarily imply that total benefits of the nonmarket good are overestimated or underestimated since some individual valuations may be negatively biased while others in the same survey may be positively biased. However, the probability of unbiased aggregate benefit measures would be expected to increase as bias in individual valuations is reduced. To a large extent, the success of any contingent valuation study would seem to depend on how well the investigator is aware of and understands the biases that may occur and to what extent he takes measures to limit their influence. The remainder of this section will present the major biasing factors which have been suggested in recent years and the evidence concerning their extent.

STRATEGIC BIAS---Of all the biases presumed to affect contingent valuation studies, none has been the focus of more attention than strategic bias. Identified early on, strategic bias occurs when the respondent believes that he may be able to influence the outcome of the study by strategically misstating his true valuation of the nonmarket good. For example, "an environmentalist who thinks his bid might affect some environmental policy may bid higher than his true willingness to pay in order to increase the average bid, provided he knows he will not have to pay based on these bids. Alternatively, if an individual believes his payment will be based on responses given to the questions, there will be incentives to conceal true preferences provided the individual is reasonably sure the good will be provided (EPA, 1983, p. 4-4)."

Results of studies designed to detect strategic bias almost without exception indicate that strategic bias is not a serious problem (Brookshire, Ives, and Schulze, 1976; Rowe, d'Arge, and Brookshire, 1980). In fact, compared to the fears held by early researchers, strategic bias appears to be the least important potential bias limiting the viability of contingent valuation. Despite these results however, it is still generally advised that the interviewer stress that the respondent's bid will not directly result in future additional personal costs or improved facilities. Such an approach of establishing low consequence realism must be considered superior to making "counter strategic and moral arguments" (Bohm, 1971) which amount to little more than moral suasion.

PAYMENT VEHICLE BIAS---In order to make the hypothetical market more credible to the respondent, a specific method of payment is normally explicitly stated in the elicitation process. If the investigator desires a willingness-to-pay estimate, he may specify an increase in access fees as the vehicle through which the individual's bid would be collected. Alternative payment vehicles might include higher utility payments, increased taxes, direct cuts in payroll, etc. Payment vehicle bias is said to exist when the respondent is influenced by the particular payment vehicle selected. For example, some individuals might harbor deep resentment toward payment through taxes, especially if recent changes in tax laws have significantly increased their tax burden. As a result, it is conceivable that they might understate their true willingness-to-pay, or simply refuse to participate if increases in taxes were the selected payment vehicle.

The empirical evidence on the existence of payment vehicle bias has been somewhat contradictory. Some investigators, on the basis of their own studies have concluded that it is a significant problem (Greenley, Walsh, and Young, 1976; Rowe, d'Arge, and Brookshire, 1980), while others have found no evidence of payment vehicle bias (Randall et. al., 1974, 1978). In their 1980 study, Rowe, d'Arge and Brookshire systematically examined the extent of vehicle payment bias by comparing willingness-to-pay estimates obtained through hypothetical utility bill increases versus deductions in payroll. Their results indicated that the choice of the payment vehicle could have a significant effect on willingness-to-pay.

STARTING POINT BIAS---Starting point bias is said to occur when the choice of a starting value for iterative bidding approaches influences the final willingness-to-pay estimate of the individual. Some individuals may interpret the initial starting point amount as an approximately appropriate bid. As such, if their true valuation is considerable less than the starting point, they may upwardly revise their valuation in an attempt to please the interviewer or in an attempt to give a response which is in some sense more socially acceptable. Alternatively, if their true valuation is much greater than the starting point, they may downwardly revise their estimate so that they will not appear foolish or extravagant.

Just as with payment vehicle bias, the evidence regarding starting point bias is mixed. However, the preponderance of this evidence seems to indicate that starting point bias should be a serious concern when employing iterative bidding techniques. For example, Rowe, d'Arge, and Brookshire (1980) in their study designed to evaluate the total willingness-to-pay for improvements in air quality in and around Farmington, New Mexico found "strong evidence of the effects of starting points, with a respondent's bid for improvements in visibility increasing by $0.60 for every $1.00 increasing in the starting point (EPA, 1983, p. 4-6)." Additionally, in an EPA study (1983) of the value of improvements in water quality in the Monongahela River, bidding games with $25 and $125 starting points were shown to result in statistically different benefit estimates. Estimates based on the $125 starting point bidding games exceeded those of the $25 starting point games by a factor of five.

HYPOTHETICAL BIAS---Of all the biases which may affect contingent valuation survey results, none would appear to be more basic or potentially more serious than hypothetical bias. While it is possible to minimize the occurrence and test for other forms of bias, by its very nature contingent valuation is based upon a hypothetically structured market. Therefore, the opportunities for reducing hypothetical bias are extremely limited. In addition, in attempting to correct for one or more of the above mentioned biases, the potential for hypothetical bias may be increased. As Myrick Freeman (1979) recently observed,

> ...devices to eliminate incentives for biased responses also have a second effect. They reduce the incentive to provide accurate responses. An accurate response is one which would be revealed if the good in question could actually be offered in a market. In the real world, an individual who takes an action inconsistent with his basic preferences, perhaps by mistake, incurs a cost or a loss of utility. In the purely hypothetical survey situation, there is no cost to being wrong, and therefore no incentive to undertake the mental effort to be accurate. The more hypothetical the situation posed to the individual; that is, the further removed the situation is from his normal everyday experience, the less likely is the answer to be accurate. This problem has not yet been addressed seriously.

The essence of hypothetical bias is that because contingent valuation exercises are purely hypothetical, some if not many individuals may find it extremely difficult, or may not undertake the considerable mental effort, to state their valuation of the nonmarket good in question. It will be obvious that some respondents will have difficulty with hypothetical bias in that they will be unable or unwilling to participate. In other cases though, an individual may experience difficulty with the hypothetical nature of the process, but will simply "fake it", introducing an unknown element of bias in the survey's results. It is small wonder that some individuals are affected by hypothetical bias. In employing contingent valuation techniques, the investigator asks that the respondent make explicit dollar valuations on the basis of descriptions of hypothetical circumstances concerning things which the respondent has previously never had to consider. Bishop and Heberlein (1979) expand on this point in the following way.

> When people buy things in a market, they may go through weeks or months of considering the alternatives. The process will often involve consultations with friends and may also involve professionals such as lawyers or bankers. It may also entail shopping around for the best deal on the product in question. And for the majority of items in the consumer's budget, there is a whole history of past experience in the market to base the decision on. All this is markedly different than spending an hour or two at most with a mail survey or a personal interviewer attempting to discern how one might behave in a market for a commodity for which one has never actually paid more than a nominal fee.

Only two known studies have attempted to explicitly test for the existence of hypothetical bias. In both cases hypothetical valuations have been compared to actual valuations. Bohm (1971) compared willingness-to-pay estimates from individuals for public television to actual payments made by a subset of the survey population. Those included in the actual payment subset were given money to spend on a number of different alternatives including public television. Results of this comparison showed that the willingness-to-pay bids from the individuals who actually had to pay were significantly less than those who were simply asked to give their hypothetical valuations. In the second study, Bishop and Heberlein (1979) undertook to, among other things, compare the actual willingness-to-sell of hunters holding early season goose hunting permits in East Central Wisconsin with their hypothetical willingness-to-sell. Based upon the acceptance of actual cash offers, actual willingness-to-sell was determined to on average amount to $63 per permit while hypothetical willingness-to-sell averaged $101.

4.2.3 *Contingent Ranking*

Partially as a result of serious concerns regarding the effects of hypothetical bias on contingent valuation results, researchers in the late 1970s and early 1980s began to search for different approaches to contingent valuation which would place the respondent in a situation more like his normal everyday experience. One product of that search was the technique of contingent ranking. First proposed by Beggs, Cardell, and Hausman in 1981 as a technique for estimating the demand for potential goods and services (goods and services not presently produced but potentially producible), the contingent ranking technique is essentially an extension of the random utility/conditional logit model associated with McFadden (1974). Like other contingent valuation formats, the contingent ranking approach is based upon the responses of individual consumers contingent upon the existence of a hypothetical market. In this approach, respondents are presented with a finite set of alternative states of the world and representative costs to the respondent of achieving each state. The individual is then asked to array the combinations of states and costs from that which he most prefers to that which he least prefers. Based upon these rankings and information concerning the characteristics of the ranked alternatives and the individual, it is possible to estimate Hicksian income-compensated measures of welfare adjustment for *changes* from one state to another.

In contrast to the other contingent valuation methods previously discussed, the contingent ranking format does not require that the individual directly provide his monetary valuation of the nonmarket good or service under consideration. Instead, it presents the respondent with the seemingly less threatening and less complex task of arranging a set of alternatives from most to least preferred based upon their characteristics and costs. In this way the contingent ranking format places minimum demands upon the respondent and assumes only the most basic condition of consumer behavior; specifically that the consumer is "able to compare alternative commodity bundles and to determine his or her order of preference among them (Gould and Ferguson, 1980, p. 13)". The implicit assumption underlying contingent ranking is than "an individual is better able to respond to the hypothetical market when both outcomes (*price and characteristics of alternatives*) are specified (EPA, 1983, p. 2-14)". Because the ranking process is in some sense more "price stable" than the iterative bid technique in which price is continually changing and the direct question in which there is little or no price information given to the respondent, the contingent ranking format places the individual in a contingent setting which is more similar to the consumer economy in which he normally operates; where prices for various goods and services are for the most part predetermined. For this reason, the contingent ranking technique has the capability to be less prone to the problems posed by hypothetical bias. However, while the contingent ranking format asks a simpler task of the respondent, the approach requires more sophisticated and less direct techniques to estimate the value of the outcomes.

4.3 *METHOD SELECTION*

In determining how to best approach the valuation of water resource information within the domain of nonmarket valuation techniques, consideration was given to the theoretical appropriateness of each of the techniques previously discussed. In addition, due to time and financial constraints, a mail survey approach to data collection was determined to be a practical necessity for this study. Consequently, the choice of a nonmarket valuation technique had to consider not only theoretical appropriateness but also compatibility with the mail survey form of elicitation.

Chavas and Pope (1984), in considering possible approaches to the valuation of information, suggest that both the general travel cost approach and contingent valuation methods are both possible approaches to the problem. While not a travel cost model in the strict sense, Chavas and Pope outline how a necessary marketed input to the learning process, such as managerial time, could theoretically be used as a proxy for the price of information in the same way travel cost is used for outdoor recreation. They conclude that "the demand for necessary informational inputs can provide an appropriate measure for information valuation (1984, p. 709)".

In considering the use of contingent valuation techniques to value information, Chavas and Pope suggest that iterative bidding games could be directed at respondents "in an attempt to determine their willingness to pay for a particular message or a particular experiment (1984, p. 709)". However, they voice the concern that value estimates arrived at in this way may be biased, presumably due mostly to the highly hypothetical setting. They conclude that "too little work has been done on this subject to properly evaluate the merits of the contingent valuation approach in the analysis of information value" and that "further research comparing the relative merits of the alternative approaches just discussed seems greatly needed (p. 709)".

While, from a purely theoretical standpoint, it would seem that the travel cost and conventional contingent valuation techniques are similar in that they could both be applied to the valuation of information, the practicality of employing these techniques in the present case was judged to be limited. Notwithstanding the suggestion of using costs of managerial time as a proxy for the price of information, it was expected that use of a "travel cost" approach to the valuation of water resource information would meet with significant elicitation difficulties. Unlike the recreationist who is for the most part aware of the transportation costs he incurs to travel to a particular recreational site, it is doubtful that the water resource decision maker could recall with sufficient accuracy the manner in which he allocates his limited managerial time across particular water information items. Further, in the course of their managerial duties, it seem likely that most water resource decision makers do not deal with single items of water information at a time, but consider many informational items simultaneously. If this is the case, the use of managerial time cost as a proxy for the price of information might encounter a problem similar to the multiple destinations issue in conventional travel cost analysis. Because the information items are jointly consumed, there exists no theoretically defensible way to partition managerial time costs. Notwithstanding the fact that the "travel cost" method would be compatible with a mail survey elicitation procedure, the use of this approach to the valuation of water resource information was rejected.

Conventional contingent valuation techniques were also determined to be inappropriate to the valuation of water resources information. As indicated previously, iterative bidding techniques, because of the interaction required between the interviewer and the respondent in determining maximum willingness to pay, for the most part exclude the use of mail surveys. Additionally, close-ended direct question techniques, while compatible with the mail survey format, are limited precisely to the extent that they do not capture maximum willingness to pay. This would appear to leave the open-ended direct question technique as a possible water information valuation approach. However, consideration of that technique reemphasizes a fundamental problem with the use of this, as well as the other conventional contingent valuation techniques in the present setting. That problem is hypothetical bias. While hypothetical bias may not be a significant source of concern in typical contingent valuation analyses where individuals are queried concerning the amount of their personal income they would be willing to pay to obtain or forestall some object or event, this is not the case when water resource decision makers are asked how much of their agency's budget they would spend for a particular item of water information. The reason for this is that individual's, although they may never have considered what they would be willing to pay for a particular nonmarket good or service, *are* experienced in making decisions which affect their personal incomes. Conversely, few water resource decision makers, it would be argued, have had significant experience in determining how their organization's budget is spent. As a result, asking water resource decision makers how much of their agency's budget they would be willing to spend for a given item of water information would place them in an extremely unrealistic setting. It would be expected that placing the individual in a less complex and less demanding setting would improve the reliability of the responses obtained, and increase compliance. For these reasons, the contingent ranking technique previously introduced was selected as the nonmarket valuation technique to be applied to the valuation of water resource information. Not only was this approach expected to reduce potential problems associated with hypothetical bias, but as shown in this study, the approach was also determined to be adaptable to mail survey techniques. Consequently, the following sections present the contingent ranking approach in greater detail with special emphasis given to the theory of consumer utility maximization which underlies this method.

4.4 *THE RANDOM UTILITY MODEL*

In the neoclassical theory of consumer utility maximization the individual is assumed to consume some positive amount of every commodity which enters into his utility function. This assumption is imposed, in part, so that so-called corner solutions can be avoided. More importantly however, this condition exists because of the marginalist tradition of neoclassical economic theory. Due to the way in which modern economic theory has developed, the attention of economists has most often been directed toward how the individual alters his consumption at the margin in response to exogenous changes in economic factors. As a result, interest has typically been shifted away from choice at the extensive margin (Should I consume A or B or neither?) and toward the intensive choice margin (How much more of A should I consume if I decrease consumption of B?). While this orientation has been shown to be of unquestionable value in the analysis of countless economic issues, some choice situations are by their very nature discrete in character. In these situations, the neoclassical theory of consumer choice, and the modifications which are sometimes proposed to deal with "lumpy" goods, may be inadequate. As argued in Chapter 2, demand for water resource information and derived demand for water resource data are well suited to interpretation as discrete choice problems. The random utility model has been proposed as one approach for dealing with discrete consumer choices.

In the random utility model, consumers are assumed to face a finite set of commodity alternatives, each having certain implications for the individual's level of utility.

Further, individual's are assumed to possess utility functions affected by these alternatives and their characteristics, and the characteristics of the individual. The consumer's choice problem is to select that alternative which maximizes his utility. Decisions are made within a discrete choice framework. Because utility is dependent upon the characteristics of the individual, the random utility model "generally replaces the assumption of a common behavioral objective function across individuals with the assumption of a distribution of objective functions (EPA, 1983, p. 6-3)". Because there exists a distribution of individuals, the model describes the consumer choice process using conditional probabilities. In other words, each alternative has some likelihood of being chosen "based on its characteristics, the other alternatives available and their features, *and the attributes of the individual selected* (EPA, 1983, p. 6-3, emphasis added)".

The assumptions of the random utility model can be summarized in the random utility function presented below. As the equation indicates, the utility the *ith* individual derives from the *jth* alternative is affected by two principle components; a nonstochastic component $V(z_i,a_j)$ describing representative tastes in the population, and a stochastic component $\varepsilon(z_i,a_j)$ representing the particular tastes of the *ith* individual. Moreover, each component is a function of the characteristics of the *ith* individual, z_i, and the attributes of the *jth* alternative, a_j.

$$U_{ij} = V(z_i,a_j) + \varepsilon(z_i,a_j)$$

where:

U_{ij} = utility of the *ith* individual for the *jth* alternative;
$V(z_i,a_j)$ = Nonstochastic portion of the random utility function reflecting representative tastes in the population of interest;
$\varepsilon(z_i,a_j)$ = stochastic portion of random utility function reflecting the idiosyncrasies of taste of the *ith* individual
z_i = vector of characteristics of the *ith* individual
a_j = vector of attributes of the *jth* alternative.

Because the individual is assumed to select the alternative which maximizes his level of utility, the probability that any given alternative is chosen is equal to the probability that the utility of the alternative exceeds that of all other available alternatives. Mathematically this is expressed in the following way.

$$P(\text{jth alternative chosen}) = P(U_{ij} > U_{ik} \text{ for all } k \neq j)$$
$$= P(V(z_i,a_j) + \varepsilon_{ij} > V(z_i,a_k) + \varepsilon_{ik}, \text{ for all } k \neq j)$$
$$= P(V(z_i,a_j) - V(z_i,a_k) > \varepsilon_{ik} - \varepsilon_{ij}, \text{ for all } k \neq j)$$

By making distributional assumptions concerning the additive error term in the last equation, the probability statement can be defined in terms of observable parameters (characteristics of the individual and attributes of the alternatives). Assuming an extreme value distribution, (in this case the logit distribution), the probability of the *ith* individual choosing the *jth* alternative may be expressed as:

$$P(U_{ij} > U_{ik} \text{ for } i \neq k) = (e^{V_k}) / (e^{V_k} + e^{V_i})$$

The presentation to this point is entirely consistent with McFadden's conditional logit model in which the probability that an individual will choose one alternative from a group of alternatives is explained. In keeping with that general model, conventional constraints to choice such as commodity prices and income have not been explicitly considered. However, it is possible to interpret the $V(z_i,a_j)$ component of the random utility function as the result of a constrained maximization process in which prices and income are considered by the consumer. Given this assumption, it is possible to view $V(z_i,a_j)$ as an indirect utility function including the individual's characteristics, the attributes of the alternatives, income, and prices of alternatives. Moreover, as "McFadden (1981) has suggested, $V(z_i,a_j)$ can be regarded as an indirect utility function, even in applications where it has been specified as linear in its parameters. This interpretation is possible because any continuous function can be approximated to any desired degree of accuracy with a linear specification (EPA, 1983, p. 6-4)." Consequently, rather than offering a completely different theory of consumer behavior, the random utility model recognizes those factors which conventional consumer theory indicates are important to choice (prices, income, and preferences) while adapting the theory to explicitly account for discrete choice.

The random utility model would appear to be particularly well suited to modeling the demand of water resource decision participants for water resource information. In the course of the organizational decision process, decision participants are faced with a variety of information items. Some of these items are more directly related to the issue under consideration than are others. In addition, some information items, within any given organization, have greater symbolic impact than do others. Consequently, information item values vary as do their costs of acquisition. Acquisition costs may include the internal costs of necessary data collection and analysis or may simple represent payments for information received from other sources. Because particular information items are fundamentally indivisible commodities (Arrow, 1962; Stigler, 1968) and because the organization operates within a limited budget, the decision participant's choice problem is to choose from among the set of discrete information items so as to maximize utility as it relates to the organizational decision process. Random utility theory tells us that this choice process will be dependent upon the characteristics of the information items (appropriateness to the problem, symbolic impact), and the relevant characteristics of the individual (disciplinary training, professional responsibilities, etc.).

4.5 *ESTIMATION OF THE RANDOM UTILITY MODEL USING INDIVIDUAL RANKINGS*

Building upon the random utility/conditional logit model just presented, Beggs, Cardell and Hausman (1981) were the first to suggest estimation of the random utility model using data on individual rankings of alternatives; data reflecting an individual's ordering of a set of discrete alternatives from most to least preferred. Unlike McFadden's general conditional logit model, the ordered logit model explicitly takes into consideration the additional information which rankings of alternatives provide. Because conditional logit analysis considers only which *one* of a number of alternatives an individual selects as most preferred, conditional logit models predict only how incremental changes in explanatory variables will affect the probability that a particular alternative is selected as most preferred. The ordered logit/contingent ranking approach, however, by considering complete individual ordering of alternatives from most to least preferred, enables description of the probability of a complete ordering of alternatives, rather than just the most preferred element. In a straightforward extension of theory, Beggs, Cardell and Hausman showed that the probability of a particular ordering of alternatives by an individual is equal to the probability that the utility derived from the highest ranked alternative exceeds that of the next higher ranked alternative which in turn exceeds that of the next higher ranked alternative, etc. Assuming as before that the additive error terms follow a logit distribution, Beggs, Cardell and Hausman showed that the closed form likelihood for any given ordering of alternatives by an individual is as follows.

$$P(U_1>U_2>U_3>\ldots>U_h) = \prod_{k=1}^{H} (\exp(V_k))/\sum_{i=k}^{H} (\exp(V_i))$$

where:

H = number of alternatives considered.

That is, for a finite set of alternatives presented to an individual, the probability that the utility derived from the highest ranked alternative exceeds that of the next higher ranked alternative, etc., equals the product of the expression in parentheses for all available alternatives. Under the assumption that each individual's decision concerning the ordering of alternatives is independent of other individuals, the likelihood function for a sample of T individuals appears as:

$$L = \prod_{j=1}^{T} \prod_{k=1}^{H} (\exp(V_{jk}))/\sum_{i=k}^{H}(\exp(V_{ji}))$$

Taking the natural logarithm of both sides of this equation yields the log-likelihood function which is normally most amenable to estimation through the method of maximum likelihood. Because of the nonlinearities within the log-likelihood expression, estimation is normally carried out through the use of an iterative maximization algorithm such as Newton-Raphson or Davidon- Fletcher-Powell. Whichever maximization algorithm is selected, the result of the ordered logit estimation will be a set of estimates for the unknown parameters of the nonstochastic portion of the random utility function, V(z,a), which as indicated previously, can be interpreted as an approximation to a representative indirect utility function for the population sampled. Because estimation of the random utility model using ranked data results in scaled or normalized parameter estimates (relative to standard error), direct inspection of the estimates does not permit evaluation of utility associated with specific alternatives. However, consistent with the interpretation of V(z,a) as an approximation to an indirect utility function, it is possible to estimate Hicksian compensating surplus measures associated with *changes* from one alternative to another. To demonstrate how this is done, assume that the non-stochastic portion of the random utility function is specified in the following simple way:

$$V = B_1A_1 + B_2Z_1 + B_3Y$$

where:

A_1 = first attribute of the ranked alternatives;

Z_1 = first individual-specific characteristic;

Y = personal income.

It may be helpful to think of A_1 as a nonmarket good or service, such as air quality, which can vary over some predetermined range. If the value of improvements in air quality were to be estimated, the alternatives presented to the respondent for ranking would reflect differing levels of air quality and the related costs to the individual of achieving those levels. Totally differentiating the estimated equation would yield the following expression:

$$dV = B_1\ dA_1 + B_2\ dZ_1 + B_3\ dY$$

Holding change in utility constant (dV=0), and assuming that individual specific characteristic Z_1 remains unchanged ($dZ_1=0$), the change in the representative individual's income necessary to offset a given change in A_1 is equal to:

$$dY = - (B_1 / B_3) dA_1$$

Thus, by substituting the differing levels of air quality presented to the sample group of respondents, representative Hicksian compensating surplus measures could be estimated for changes from one state to the next.

By making some modifications in the way the variable of interest is specified, the general approach outlined above could be used to estimate Hicksian compensating surplus measures for a finite number of information items. Instead of specifying one continuous variable (as for air quality), the nonstochastic portion of the random utility function would contain a set of dichotomous qualitative variables associated with each of a number of discrete information items. Through a parallel process of estimation, differentiation, and substitution, it would be possible to calculate the change in division budget necessary to offset changes in utility brought about by moving the water resource decision participant from one information item to the next. Such an approach would, however, only indicate the incremental value of an item of information relative to other items included in the set of available alternatives. To estimate the total value of any given information item, comparison to some minimum information set excluding that item would be required.

4.6 *PRIOR APPLICATIONS*

Because of the recent development of the contingent ranking/ordered logit approach, few prior applications of the method exist. While, as previously stated, the use of information concerning individual rankings of alternatives was first suggest in 1981 by Beggs, Cardell and Hausman, their use of the approach was not directed toward the valuation of any nonmarket good or service. Instead the purpose of their investigation was to assess the potential demand for electric automobiles.

Employing their extension of McFadden's conditional logit model, Beggs, Cardell and Hausman presented 200 respondents with 16 hypothetical automobile designs differing over 9 different attributes. These attributes included seating capacity, maximum speed, price, operating cost, and daily driving range. As would be expected, electric automobiles generally were defined to have lower maximum speeds and shorter daily driving ranges than similar gasoline powered vehicles. Based on the automobile's attributes and expected price, each respondent was asked to rank the 16 alternative designs from most preferred to least preferred. A Newton-Raphson algorithm was used to solve for the maximum likelihood estimates of the random utility function, which included both vehicle attributes as well as individual characteristics. Based on the results of that estimation they found that consumers placed a large negative valuation on limited driving range casting "considerable doubt on the possibility of much consumer demand for electric cars given the existing technology (1981, p. 2)".

Following the initial contribution provided by Beggs, Cardell and Hausman, it is believed that there have been only four other applications of the contingent ranking/ordered logit approach. Three of the applications, as reported by the U.S. Environmental Protection Agency (1983), were conducted by Douglas Rae of the Boston consulting firm Charles River Associates. In two unpublished reports (1981a, 1981b), Rae investigated the value of visibility changes in Mesa Verde National Park and in the Great Smoky Mountains National Park respectively. In a similar 1982 study Rae also investigated the value of visibility changes in and around Cincinnati, Ohio. The fourth application of the contingent ranking/ordered logit approach was undertaken by Research Triangle Institute in 1983 for the U.S. Environmental Protection Agency (EPA, 1983). Because of the unpublished nature of the Rae studies, and the fact the two 1981 studies were to some extent reviewed in the 1983 EPA report, a separate review will not be presented here.

In an attempt to compare alternative approaches for estimating the recreational and related benefits of water quality improvements, Research Triangle Institute, under contract with the U.S. Environmental Protection Agency, published its 1983 report. In this study, the value of changes in water quality for the Monongahela River were estimated in a contingent ranking framework for the express purpose of comparison with similar estimates obtained through travel cost and conventional contingent valuation methods. Approximately 300 survey respondents were asked to rank four hypothetical combinations of water quality and annual payments in the form of higher taxes and prices. Water quality, as presented to the respondent, included four categories. In order of decreasing quality these were; 1) swimming possible, 2) fishing possible, 3) boating possible, and 4) no recreation possible. While theoretically and practically these represented fundamentally discrete categorizations, they were represented in the random utility model as one continuous variable taking on the values 7.0, 5.0, 2.5, and 0.8 respectively. Payment was independent of the use made of the river during the year. Consequentially it was treated as an adjustment to income in the random utility model, rather than as a unit price.

In addition to data summarizing individual ranking and attributes of the alternatives including water quality level and payment, observations on individual characteristics were recorded. These included income, age, educational level, and dichotomous qualitative variables representing race, boat ownership, participation in outdoor recreation, and attitude toward paying for the costs of water pollution control. Individual-specific variables were entered in interaction form with one of the alternative-specific variables since, in the random utility framework, "rankings are modeled as a function of the differences between the values of the deterministic portion of the random utility function for each of the alternatives being ranked (EPA, 1983, p. 6-20)". As a simple example assume that the *ith* individual ranks the *jth* alternative as preferable to the *kth* alternative. According to random utility theory this will occur only if the utility gained from the *jth* alternative exceeds the utility gained from the *kth*. Assume further that the nonstochastic component of the random utility function, V(a,z), is a linear function of one individual characteristic Z_1, and one alternative specific attribute A_1. It follows then that:

$$V_{ij} = B_1 Z_{1i} + B_2 A_{1j}$$

and

$$V_{ik} = B_1 Z_{1i} + B_2 A_{1k}$$

As previously indicated, modeling the probability of this ordering involves maximizing the likelihood of the difference between V_{ij} and V_{ik}. Consequently:

$$V_{ij} - V_{ik} = (B_1 Z_{1i} + B_2 A_{1j}) - (B_1 Z_{1i} + B_2 A_{1k})$$

Simplifying, this expression equals:

$$V_{ij} - V_{ik} = B_2 (A_{1j} - A_{1k})$$

Therefore, as demonstrated, lone variables describing the individual can not assist in explaining how the individual ranks alternatives since they must remain constant for every alternative. In order to include these variables in explaining behavior, they must be entered in interaction form with an alternative-specific variable.

In the EPA's Monongahela water quality contingent ranking analysis, a Davidon, Fletcher, Powell algorithm was employed for maximization of the log-likelihood function. Consistent with the interpretation of the model as an approximation to an underlying representative indirect utility function, a negative sign was associated with payment, agreeing with theoretical expectations. However, a negative sign observed for the Income/Payment variable was unexpected and remained negative for all specifications of the model. *A priori* expectations would suggest that income relative to payment would be positively related to utility. Despite this seemingly serious inconsistency, the model was used to estimate compensating surplus benefits of water quality changes. As indicated previously, because ranked data provide scaled parameter estimates (relative to standard error), direct evaluation of utility changes associated with changes in water quality was not possible. However, by totally differentiating the model and holding the change in utility (dV=0) equal to zero, the change in payment necessary to offset changes in water quality was calculated. Since the payment vehicle was not, as noted earlier, a fee per unit of use but rather an adjustment to income regardless of the individual's use of the river, the measure of compensating surplus was expected to be invariant to the use of income or payment in the total differential equation. Using this approach, compensating surplus measures were calculated for each individual for changes from boatable to fishable water quality, and from boatable to swimmable water quality. Compensating surplus for the former water quality change averaged $60 per year with a range of $36 to $85. Compensating surplus for the latter water quality change averaged $110 per year with a range of $65 to $150. Based upon these estimates and upon their comparison with travel cost and conventional contingent benefit estimates for identical changes in water quality, the study concluded that the results provided stronger support for the contingent ranking method than did the previous findings of Rae (EPA, 1983, pp. 6-28).

4.7 *WATER INFORMATION VALUATION*

While, as the previous section indicates, some uses have been made of the contingent ranking/ordered logit approach for the valuation of environmental services, no known previous use of the technique for information valuation has yet been attempted. Consequently, the contingent ranking water resource information valuation approach adopted in this study borrowed heavily from the approach used by Research Triangle Institute in the 1983 EPA study of Monongahela River water quality. However, as will become evident, some major differences between the two approaches do exist.

The contingent ranking elicitation procedure employed in the survey questionnaires asked water resource decision participants to assume that they were responsible for conducting an analysis of a specific river basin management problem and for making related policy recommendation. For individuals located in the Missouri River basin the river basin management problem concerned instream versus offstream water competition. In the Chesapeake Bay drainage, water resource decision participants were asked to consider the problem of decreasing freshwater inflows to the Bay.[16] Individuals were further asked to assume that no relevant information concerning their issue was presently available to them. However, the respondent was instructed that his organization had authorized him to select one "information package" from a group of five available packages which were listed in the questionnaire. While no budget limitation had been set, the respondent was informed that the costs and the contents of the packages varied and that the cost of the information package selected would be deducted from his organization's typical annual operating budget. As a result, cost represented a yearly adjustment to the organization's budget, independent of the extent to which the

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[16] Since these management issues have been discussed in Chapter 3 at length, they will not be discussed further here.

information contained in the package was used. Based on this hypothetical scenario the respondent was requested to rank the packages from most preferred to least preferred considering both the costs of the packages, and the usefulness of the information items contained within them. A important point which should be noted is that, unlike the conventional consumer demand perspective implicit in the EPA water quality use of contingent ranking, the water resource decision participant's demand for information does not arise from needs for personal gratification. It instead is generated by his role in the organization. For both surveys, the information packages were similarly structured. One package represented a baseline bundle of information items which summarized basic hydrologic conditions of relevance to the basin and to the problem being considered. The other four information packages were identical to the baseline bundle except for the presence of one additional item of information of potential relevance to the problem issue. Costs of the information packages were structured to maintain some continuity with the water "assessment information" expenditure exercise in which the respondent had previously participated. Because of the incremental information item occurring in each of the four nonbaseline packages, costs for these packages as would be expected were somewhat greater than the baseline package. While these costs were to a large extent arbitrary, owing to the exploratory nature of this investigation, some attempt was made to capture expected relative resource outlays to provide the information. For the Missouri River basin survey the baseline information package contained the following four information items:

1) Estimates of current surface water supplies;

2) Estimates of current surface water withdrawals;

3) Estimates of current groundwater supplies;

4) Estimates of current groundwater withdrawals.

The cost of the baseline information package was set at $100,000. The remaining four packages presented to Missouri River Basin respondents included these information items plus one of the following additional items:

* Estimates of the economic value of water in various instream and offstream uses (Package #2 Cost $150,000);

* Information describing the interrelationship between surface and groundwater (Package #3 Cost $135,000);

* Forecasts of future water withdrawals by major uses (Package #4 Cost $110,000);

* Relationship between water cost or price and quantity of water demanded (Package #5 Cost $125,000).

For the Chesapeake Bay Drainage survey, the baseline information package contained the following three information items:

1) Estimates of current water supplies for Bay tributaries;

2) Estimates of current withdrawals and consumptive use for Bay tributaries;

3) Estimates of future withdrawals and consumptive use for Bay tributaries.

As in the Missouri River Basin survey, the cost of the baseline information package was set at $100,000. In addition to these three information items, the four remaining information packages presented to Chesapeake Bay Drainage water resource decision participants included one of the following information items:

* Estimates of the effects of salinity on Bay marine life (Package #2 Cost $150,000);

* Information describing water storage sites and potential storage in reservoirs located on Bay tributaries (Package #3 Cost $135,000).

* Estimates of groundwater reserves (Package #4 Cost $110,000);

* Relationship between the cost or price of water and the quantity of water consumed by tributary water users (Package #5 Cost $125,000);

It is important to note that while these particular incremental information items were more or less arbitrarily selected for valuation in this study, any other group of water information items of interest could have appeared in their place.

Unlike the Monongahela River water quality valuation approach in which four essentially discrete levels of water quality were represented in the random utility model as a single continuous variable, it was concluded that the additional water information items considered in the above alternatives could not be similarly treated. The additional water information items appearing in the nonbaseline packages represent different commodities within a larger commodity group as opposed to varying levels of a single commodity. Accordingly, these packages were represented in each basin's random utility model through the use of four dichotomous qualitative variables. Moreover, the random utility model used in the analysis of each basin's rankings included those organizational and personal characteristics which were included in the analyses of National Water Assessment use and expenditures on "assessment information" for each of the basin study contexts. Accordingly, the random utility model specification employed for the Missouri River basin rankings was as follows.

$$\begin{aligned} \text{UTILITY} = {} & B_1 \text{ BUNDLE2} + B_2 \text{ BUNDLE3} + B_3 \text{ BUNDLE4} + B_4 \text{ BUNDLE5} \\ & + B_5 \text{ COST} + B_6 \text{ FEDFLD} * \text{COST} + B_7 \text{ STATEREG} * \text{COST} \\ & + B_8 \text{ SCINV} * \text{COST} + B_9 \text{ REGMGT} * \text{COST} + B_{10} \text{ IBUDGET} \\ & * \text{COST} + B_{11} \text{ SOCSI} * \text{COST} + B_{12} \text{ PHYBIO} * \text{COST} + \\ & B_{13} \text{ PABM} * \text{COST} + B_{14} \text{ BUDP} * \text{COST} + B_{15} \text{ PPP} * \text{COST} \\ & + B_{16} \text{ AOP} * \text{COST} + B_{17} \text{ IACTIVE} * \text{COST} \end{aligned}$$

where:

BUNDLE1[a]	is a dichotomous qualitative variable representing information package one (baseline package);
BUNDLE2	is a dichotomous qualitative variable representing information package two;
BUNDLE3	is a dichotomous qualitative variable representing information package three;
BUNDLE4	is a dichotomous qualitative variable representing information package four;
BUNDLE5	is a dichotomous qualitative variable representing information package five;
COST	is the annual cost of the respective information package in $10,000 units;
FEDHOM[a]	1 if employed by Federal Government home office; 0 otherwise;
FEDFLD	1 if employed by a Federal Government regional office; 0 otherwise;
STATEREG	1 if employed by a state or regional agency; 0 otherwise;
DVLPLN[a]	1 if agency mission was developmental-planning; 0 otherwise;
SCINV	1 if agency mission was scientific-investigative; 0 otherwise;
REGMGT	1 if agency mission was regulatory-management; 0 otherwise;
IBUDGET	reciprocal of annual Division operating budget ($10,000 units);
ENGHY[a]	1 if training was in engineering-hydrology; 0 otherwise;
SOCSI	1 if training was in social sciences; 0 otherwise;

PHYBIO — 1 if training was in physical-biological sciences; 0 otherwise;

PABM — 1 if training was in public administration-business management; 0 otherwise;

BUDP — Decimal percent of time devoted to budget allocation/preparation;

PPP — Decimal percent of time devoted to program planning;

AOP — Decimal percent of time devoted to agency operations;

IACTIVE — Reciprocal of years of professional water resource activity.

Similarly, the random utility model specified for the analysis of contingent rankings resulting from the Chesapeake Bay Drainage survey was:

$$\text{UTILITY} = B_1 \text{ BUNDLE2} + B_2 \text{ BUNDLE3} + B_3 \text{ BUNDLE4} + B_4 \text{ BUNDLE5} + B_5 \text{ COST} + B_6 \text{ FEDFLD} * \text{COST} + B_7 \text{ STATEREG} * \text{COST} + B_8 \text{ RESPLN} * \text{COST} + B_9 \text{ ENVREG} * \text{COST} + B_{10} \text{ RESMGT} * \text{COST} + B_{11} \text{ SCINV} * \text{COST} + B_{12} \text{ IBUDGET} * \text{COST} + B_{13} \text{ SOCSI} * \text{COST} + B_{14} \text{ PHYBIO} * \text{COST} + B_{15} \text{ PABM} * \text{COST} + B_{16} \text{ BUDP} * \text{COST} + B_{17} \text{ PPP} * \text{COST} + B_{18} \text{ AOP} * \text{COST} + B_{19} \text{ IACTIVE} * \text{COST}$$

where:

BUNDLE1[a] — is a dichotomous qualitative variable representing information package one (baseline package);

BUNDLE2	is a dichotomous qualitative variable representing information package two;
BUNDLE3	is a dichotomous qualitative variable representing information package three;
BUNDLE4	is a dichotomous qualitative variable representing information package four;
BUNDLE5	is a dichotomous qualitative variable representing information package five;
COST	is the annual cost of the respective information package in $10,000 units;
FEDHOM[a]	1 if employed by Federal Government home office; 0 otherwise;
FEDFLD	1 if employed by a Federal Government regional office; 0 otherwise;
STATEREG	1 if employed by a state or regional agency; 0 otherwise;
RESDVL	1 if agency mission was natural resource development; 0 otherwise;
RESPLN	1 if agency mission was natural resource planning; 0 otherwise;
ENVREG	1 if agency mission was environmental regulation; 0 otherwise;
RESMGT	1 if agency mission was natural resource management; 0 otherwise;
SCINV	1 if agency mission was scientific-investigative; 0 otherwise;
IBUDGET	reciprocal of annual Division operating budget ($10,000 units);
ENGHY[a]	1 if training was in engineering-hydrology; 0 otherwise;
SOCSI	1 if training was in social sciences; 0 otherwise;

PHYBIO	1 if training was in physical-biological sciences; 0 otherwise;
PABM	1 if training was in public administration-business management; 0 otherwise;
BUDP	Decimal percent of time devoted to budget allocation/preparation;
PPP	Decimal percent of time devoted to program planning;
AOP	Decimal percent of time devoted to agency operations;
IACTIVE	Reciprocal of years of professional water resource activity.

As in previous analyses, those variables identified with a superscript "a" were eliminated from the model to avoid the dummy variable trap. In contrast to the models presented in Chapter 3, division or branch annual operating budget and years of professional activity in water resource issues were entered into the contingent ranking/random utility models in reciprocal form. Additionally, the professional responsibility variables BUDP, PPP, and AOP are here represented as decimal percentages instead of numerical percentages. Because of the sheer size of the log-likelihood function and the fact that the above specifications appear as exponents in the function, the process of maximization can produce numbers too large for computer storage. The transformation of these variables was necessary in order to avoid numerical overflow problems which would have made computer estimation of the models impossible. From a theoretical standpoint, nothing is lost in performing such transformations. The models were estimated using the same program and maximization algorithm (Davidon, Fletcher, Powell) used in the Research Triangle Institute Monongehala River water quality study (EPA, 1983).

4.8 *MISSOURI RIVER BASIN RESULTS*

Results of the maximum likelihood estimation of the ordered logit model for the Missouri River Basin are presented in Table 4.1 . The Davidon-Fletcher-Powell algorithm required 19 iterations to maximize the log-likelihood function at a value of -483.80. Interpreting the model as an approximation to an underlying indirect utility function, both the parameter estimates for COST and IBUDGET*COST exhibited the signs which theory would have suggested. Because increases in cost, *ceteris paribus*, diminish ability to purchase goods and services, increases in cost are expected to have a negative impact on utility. Conversely, increases in income (BUDGET), *ceteris paribus*, enable the individual to increase his purchases. This would be expected to have a positive effect on the individual's level of utility. Since branch or division budget is represented in the random utility model in reciprocal form

(1/BUDGET=IBUDGET), IBUDGET*COST has the predicted negatively signed parameter estimate. Inspection of the asymptotic t-ratios associated with these variables reveals that information package cost is a significant factor in explaining utility while IBUDGET*COST is not.

Parameter estimates for each of the four dichotomous qualitative variables BUNDLE2, BUNDLE3, BUNDLE4, and BUNDLE5 were also of the expected signs. Statistically these variables indicate the increment to utility brought about by consumption of each of the nonbaseline information packages relative to the baseline package. Since each of the four nonbaseline packages contained all the information items provided by the baseline package plus one additional information item, each would be expected to result in a positive increment to utility. The positive signs associated with BUNDLE2, BUNDLE3, BUNDLE4, and BUNDLE5 confirm this expectation. Inspection of the asymptotic t-ratios for these variables indicates that information packages two, three, and four result in significant utility increases to the representative Missouri River Basin water resource decision participant while the utility generated by information package five is not significantly different from that resulting from the baseline package.

TABLE 4.1

Maximum Likelihood Estimates of Contingent Ranking Model - Missouri River Basin

VARIABLE	ESTIMATE	T-RATIO
BUNDLE2	1.8165	1.6047
BUNDLE3	1.6428	1.9983
BUNDLE4	1.4854	5.1326
BUNDLE5	0.8468	1.4410
COST	-0.4361	-1.6965
STATEREG * COST	0.0792	0.7871
FEDFLD * COST	0.4182	0.3531
SCINV * COST	-0.1261	-1.2018
REGMGT * COST	-0.0518	-0.6703
SOCSI * COST	-0.1850	-1.3126
PHYBIO * COST	0.0361	0.3679
PABM * COST	0.0349	0.3908
IBUDGET * COST	-1.0814	-1.3122
BUDP * COST	0.9621	1.7426
PPP * COST	0.3182	1.6937
AOP * COST	0.1528	1.0173
IACTIVE * COST	-0.5708	-2.0681

19 Iterations using Davidon-Fletcher-Powell Algorithm
Maximum Value of Log Likelihood Function = -483.80

As surrogates for representative tastes and preferences in the sample population, the parameter estimates for the remaining individual and organizational variables included in the random utility model are difficult to interpret in any economically meaningful way. From the standpoint of judging the appropriateness of the model, correspondence of the variables discussed above with *a priori* expectation is the most important consideration. As the results indicate, the model demonstrates a high level of such correspondence.

Employing the estimated random utility model presented in Table 4.1, compensating surplus values were calculated for each individual in the sample. To accomplish this, according to the approach previously outlined, the estimated equation was first totally differentiated. Holding utility constant (dV=0) and assuming no change in individual characteristics over the short-run, the differentiated function was solved, as in the EPA Monongahela water quality study (1983), for changes in cost (dCOST). This equation appeared as:

$$\begin{aligned} dCOST = -(&1.817\ dBUNDLE2 + 1.643\ dBUNDLE3 + 1.485\ dBUNDLE4 \\ &+ 0.847\ dBUNDLE5) \;/\; (-.436 + .042{*}FEDFLD \\ &+ .079{*}STATEREG - .126{*}SCINV - .052{*}REGMGT \\ &- 1.081{*}IBUDGET + .962{*}BUDP + .318{*}PPP \\ &+ .153{*}AOP - .571{*}IACTIVE - .185{*}SOCSI \\ &+ .036{*}PHYBIO + .035{*}PABM). \end{aligned}$$

Because cost was defined in the contingent ranking elicitation procedure as a deduction from the respondent's branch or division annual operating budget and was independent of use of the information during that period, use of cost to derive information package value estimates is theoretically identical to the use of budget, our counterpart to income in conventional indirect utility expressions. Additionally, since the parameter estimate for IBUDGET*COST was shown to lack statistical significance in the present model, use of changes in cost to estimate information package compensating surplus was considered preferable. To calculate the compensating surplus for a particular information package, a value of one was substituted for the appropriate dichotomous variable representing that package while zero values were substituted for the three remaining package variables. Next, each respondent's observed values for organizational and personal characteristic variables were substituted into this equation. Since the dichotomous package variables represent increments to utility above that provided by the baseline information package, the compensating surplus values calculated in this way may be interpreted as the amount of agency budget which would have to be extracted from the water resource decision participant to leave him no better off with the nonbaseline information package than he was with the baseline package. Calculating individual values for each nonbaseline package for each individual, the average compensating surplus value for each water information package is presented in Table 4.2 .

In calculating these averages, no negative valuations were observed for any individual for any of the information packages considered. Because the nonbaseline information packages differed from the baseline package only by the inclusion of one additional item of water information, the average compensating surplus values reported in Table 4.2 can be interpreted as the incremental value attributable to the additional information item. In this way information item values with respect to specific problem contexts can be estimated. Such interpretation, however, is based upon the assumption that the value of a particular information package, or more generally the value of an information system, is equal to the summation of the values of its constituent parts. If, because of their complementary nature, some information items are worth more in combination with other items than they are on their own, this interpretation may not apply.

TABLE 4.2

Mean Values for Incremental Information Items - Missouri River Basin

BUNDLE	AVG COMPENSATING SURPLUS
BUNDLE2	$86,269
BUNDLE3	$78,020
BUNDLE4	$70,546
BUNDLE5	$40,218

Note: These values are provisional on the information package costs employed in the contingent ranking elicitation procedure. Accordingly they should not be interpreted as definitive values for the information items they represent.

4.9 *CHESAPEAKE BAY DRAINAGE RESULTS*

Results of the maximum likelihood estimation of the ordered logit model for the ranking data collected in the Chesapeake Bay Drainage survey are presented in Table 4.3 . In this case the Davidon-Fletcher-Powell algorithm required 20 iterations to maximize the log-likelihood function at a value of -689.50. Again, the model was interpreted as an approximation to an underlying indirect utility function. In this case, however, while the parameter estimates for COST carried the sign which economic theory would suggest, the estimate associated with IBUDGET*COST exhibited a positive sign. As explained above, increases in income (BUDGET), *ceteris paribus*, enable the individual to increase his purchases thus enabling him to enjoy a higher level of utility. Since branch or division budget is represented in the random utility model in reciprocal form (1/BUDGET=IBUDGET), IBUDGET*COST would be expected to exhibit a negative sign. Inspection of the asymptotic t-ratios associated with COST and IBUDGET*COST revealed that neither variable was statistically significant in explaining utility.

Parameter estimates for each of the four dichotomous qualitative variables BUNDLE2, BUNDLE3, BUNDLE4, and BUNDLE5 were, as expected, positively signed. As for the information packages considered in the Missouri River Basin survey, the asymptotic t-ratios for these variables indicated that information packages two, three, and four resulted in significant utility increases to the representative Chesapeake Bay water resource decision participant while the utility generated by information package five was not significantly different from that resulting from the baseline package.

Compared with the results of the Missouri River Basin contingent ranking analysis, the results of the Chesapeake Bay ranking model were clearly less encouraging. Not only did the budget variable exhibit a sign contrary to what theory would indicate, but both cost and budget were shown to be statistically insignificant. Despite these problems, however, estimates of compensating surplus were calculated as in the Missouri River Basin analysis. However, it was acknowledged that the meaning of these estimates, given the weakness of the model in this instance, is less clear than in the previous context. Holding utility constant (dV=0), assuming no change in individual characteristics over the short-run, and solving for change in cost, the differentiated function for the Chesapeake Bay rankings appeared as:

$$dCOST = -(1.254\ dBUNDLE2 + 0.954\ dBUNDLE3 + 0.771\ dBUNDLE4 + 0.239\ dBUNDLE5) / (-.026 + .084*FEDFLD - .037*STATEREG + .045*RESPLN - .002*ENVREG + .025*RESMGT - .142*SCINV + 0.885*IBUDGET + .596*BUDP - .293*PPP - .102*AOP$$

TABLE 4.3

Maximum Likelihood Estimates of Contingent Ranking Model - Chesapeake Bay Drainage

VARIABLE	ESTIMATE	T-RATIO
BUNDLE2	1.2536	1.6919
BUNDLE3	0.9541	1.8145
BUNDLE4	0.7708	3.9609
BUNDLE5	0.2388	0.6203
COST	-0.0240	-0.1203
STATEREG * COST	-0.0368	-0.5689
FEDFLD * COST	0.0839	1.0567
RESPLN * COST	0.0449	0.3955
ENVREG * COST	-0.0021	-0.0204
RESMGT * COST	0.0245	0.2467
SCINV * COST	-0.1415	-1.3188
IBUDGET * COST	0.8851	1.3718
BUDP * COST	0.5958	1.5168
PPP * COST	-0.2935	-1.7075
AOP * COST	-0.1018	-0.8566
IACTIVE * COST	0.1833	1.2494
SOCSI * COST	0.0045	0.0331
PHYBIO * COST	-0.0323	-0.5059
PABM * COST	0.0277	0.2496

20 Iterations using Davidon-Fletcher-Powell Algorithm
Maximum Value of Log Likelihood Function = -689.50

+ .183*IACTIVE + .004*SOCSI - .032*PHYBIO

+ .027*PABM).

As before, to calculate the compensating surplus for a particular information package, a value of one was substituted for the appropriate dichotomous variable representing that package while zero values were substituted for the three remaining package variables. Next, each respondent's observed values for organizational and personal characteristic variables were substituted into this equation. Calculating individual values for each nonbaseline package for each individual, the average compensating surplus value for eaqh water information package is presented in Table 4.4 . In contrast to the compensating surplus values calculated in the Missouri River Basin context, some negative individual valuations were observed for some information packages. This same outcome was experienced in some of the estimates of water quality value for the EPA Monongehala River study. Such results are clearly implausible since they imply that a person is made worse off by receiving an additional item of information.

TABLE 4.4

Mean Values for Incremental Information Items - Chesapeake Bay Drainage

BUNDLE	AVG COMPENSATING SURPLUS
BUNDLE2	$24,907
BUNDLE3	$18,956
BUNDLE4	$15,313
BUNDLE5	$ 4,745

Note: These values are provisional on the information package costs employed in the contingent ranking elicitation procedure. Accordingly they should not be interpreted as definitive values for the information items they represent.

4.10 *SUMMARY*

The preceding applications of the contingent ranking technique were undertaken primarily to demonstrate how information values could be estimated as a result of the consumer demand orientation adopted in the general conceptual framework. In the next chapter, a demonstration of how such values could be used to aid data system design will be offered. Estimation of the specific values in this study were intended only to illustrate the technique and assess its potential for future use in design situations. The validity of such values is highly dependent upon the relative magnitudes of information package costs as they are represented to respondents. Because these costs were only assumed in this study and were not based upon verified collection costs, it should not be inferred that the compensating surplus values for the information items considered reflect accurate representative willingness to pay measures.

As in the analyses of expenditures on assessment information, results from the Missouri River basin contingent ranking analysis were superior to those obtained in the Chesapeake Bay analysis. In the Missouri River basin analysis, both the variables representing price and income were correctly signed, relative to interpretation of the estimated random utility equation as an indirect utility function, and price was shown to be statistically significant. Based on the calculation of compensating surplus values, all individuals in the Missouri River basin sample group exhibited positive utility gains resulting from the addition of a marginal item of information to their information set. In the Chesapeake Bay drainage analysis, however, of the two key economic variables, only the variable representing price was signed consistent with *a priori* expectations, and neither price or income were statistically significant. In addition, compensating surplus values for several individuals in the Chesapeake Bay drainage sample group indicated that the addition of an additional item of water information to their baseline package would decrease their utility. This result is clearly implausible. In attempting to explain the marked difference between the results from these two basins, the same general factors proposed in the former analyses were presumed to largely account for this outcome.

Chapter V

DATA SYSTEM DESIGN BASED ON INFORMATION VALUES

5.1 *PURPOSE AND CONTENT*

The purpose of this chapter is to present a model of data system design based upon an integer programming framework. Consideration of this model will illustrate how information item values, such as those estimated in the previous chapter, may be beneficially used to promote greater efficiency in data collection. Further consideration of this model will also suggest other principles relevant to the design of data systems. First an integer programming problem in data system design is presented which links information values and information production requirements with data costs. Using this model, overall budget constraints are varied to draw conclusions regarding how data planners should respond to increases in data collection funds and decreases in funds if their goal is to provide data which has the greatest relevance to water resource decision participants.

5.2 *INTRODUCTION*

In the preceding chapters in which the empirical applications of the general information demand model were presented, interest was focused primarily upon information. Specifically, the effects of personal and organizational characteristics on the demand for information and water resource decision participant willingness to pay for different water resource information items were investigated. Referring once again to the Bonnen information system model presented earlier, it is clear that information is produced through the collection, analysis and interpretation of water data. With estimates of the value of different water information items, attention ultimately turns to the determination of what data are required to produce certain types of information, and which of these data will be collected.

Water data are varied and costly to collect. They are of value to the extent that water resource information which is produced from them is of value to individuals involved in water resource management. Because water resource management has been an activity which has traditionally been conducted by the public sector, water data collection is centered almost totally within the public water resource management agencies. As indicated previously, because of concern over declining budget allocations for water data collection and the impact this might have on the effectiveness of their water management efforts, public water resource management agencies are presently seeking ways to increase the efficiency of their data investment programs.

If water data and water resource information were finely divisible private goods traded in competitive markets and if water data were subject to continuous substitution in the production of water resource information, the conditions for efficient production of information and for investment in data could be readily drawn from economic theory. Specifically three conditions would have to be met: 1) the rate of product transformation between every pair of informational outputs would have to equal the ratio of their marginal valuations; 2) the value of the marginal product for all types of water data with respect to each informational output would have to equal the marginal cost (price) of the data; 3) the rate of technical substitution between each pair of data inputs would have to equal the ratio of their marginal costs (price). Clearly, however, water data and water resource information are not private goods traded in competitive markets. Consequently, we observe no market derived prices through which efficiency condition one could be determined. Moreover, water data and water information are perhaps best treated as discrete commodities, similar to consumer durables, as opposed to finely divisible commodities. This view is supported by the observation that data and information provide a stream of services over time and that the relevant decision which often confronts the data system designer is a discrete choice problem; "Should data item "A" be included or omitted from the data collection program?". Finally, it would appear that different forms of data are not subject to continuous substitution in the production of information. For example, in the production of information concerning agricultural water use, more data concerning transportation and storage losses will in general not offset less data concerning irrigation application rates.

Based on the foregoing discussion, the conventional conditions for efficient production and resource use would seem to be of limited use in the design of water data and information systems. However, a reasonable alternative approach to the efficient data system design problem might be to allocate limited data collection funds across discrete water data items so that the sum of the user values for the water information items producible is maximized. Determining the users of information produced from the data system is complicated by the public good nature of water information. In the extreme it might be argued that everyone is a user since use by one individual does not preclude use of the same information by another. More practically though, on the basis of legislative intent and patterns of use, the principle users of public water resource information can be considered to be primarily state and federal water resource decision participants. Whatever criteria is used to establish the users of an information system, it should be recognized that the design of the resulting data system will to a large extent be dependent upon whose valuations are included and whose valuations are omitted.

To fully implement this alternative approach for determining efficient data system content, it would be necessary for the water data collection agency to identify all currently collected data items as well as those which might be collected. This would include data collected by the agency as well as data collected by other water management agencies. Based upon existing records or upon engineering studies, the collection costs for all data items would be established. Next, production relationships between water data and water resources information would need to be specified. The principle source for determining these linkages would be found in underlying scientific theory. Additionally such relationships could be discerned by polling water resource professionals and scientists to arrive at some disciplinary consensus. Finally, water resource information item values for each individual in the established user population would need to be elicited. Following this, all individual valuations for a specific information item would be summed and the corresponding data interpretation and analysis costs required to provide that item subtracted from its total value. With this considerable amount of information, it would then be possible for the water data collection agency to determine the water data system which would result in maximum water information value to users.

Because of the large amount of information required to determine an overall efficient design for a water data system, it seems unlikely that massive redesign of the federal water data system would be forthcoming. However, a more practical and potentially beneficial use of the approach would be found in assisting the design of data system content at the margin. Suppose, for example, that a particular water resource management agency decided that it would expand its annual data collection expenditures by some given amount. Wishing to allocate this increment to expenditures among proposed data items so as to maximize the value of potential water resource information, the agency would again determine what items of water data were presently being collected. However, in this instance, only the costs of the proposed water data items would be required since the costs of currently collected data would be fixed with respect to the marginal data investment decision. Next, all potential new water information items producible by combining the proposed new data items with the existing data system would be established and user valuations for each item obtained. Based on the smaller information demands of this situation, agency data system designers could identify the marginal data collection strategy that would result in the largest additions to water information values. An example of this situation is depicted in Table 5.1 where the representative compensating surplus estimates for the additional information items considered in the Missouri River Basin contingent ranking exercise are employed.

As the Table indicates, it has been assumed that six different water data items are required for the production of the four incremental information items considered in the Missouri River Basin ordered logit analysis. Information item number one (I_1), estimates of the economic value of water in various instream and off-stream uses, requires the input of data items D_1 and D_6. Water information item two (I_2), information describing the interrelationship between surface and groundwater, requires the input of data items

TABLE 5.1

Marginal Data Investment Example

Potential Information Item	Average Value ($1000)	Required Data Items
I_1	86	D_1, D_6
I_2	78	D_2, D_3, D_5
I_3	71	D_2, D_3, D_4
I_4	40	D_2, D_3

Data Items	Collection Cost ($1000)
D_1	27
D_2	20
D_3	21
D_4	14
D_5	21
D_6	0

D_2, D_3, and D_5. I_3, forecasts of future water withdrawals by major uses, requires the input of D_2, D_3, and D_4. Lastly, data items D_2 and D_3 are essential for the production of I_4, the relationship between water cost or price and quantity of water demanded. If one or more of the data items associated with a particular item of water resource information are missing, it is assumed that production of that information is impossible. Additionally, because it has been assumed that data item six (D_6) is already being collected for other purposes, its collection cost with respect to the present decision is set at $0. In this instance, data interpretation and analysis costs are assumed to be minimal. A total of $55,000 has been allocated for data acquisition at the margin. Because the water management agency's goal is select those data items which will maximize the value of the information produced while remaining within their $55,000 budget constraint, their problem can be modeled within a pure zero-one integer programming framework. The integer programming specification for this example is illustrated in Figure 5.1 .[17]

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[17] If data and information are assumed to be discrete commodities, the general integer programming model for data system design is:

$$\text{MAX} \quad \sum_{i=1}^{n} (B_i - A_i)\, I_i$$

$$\text{S.T.} \quad m_i I_i - \sum_{k=1}^{m_i} L_{ik} D_k \le 0 \quad \text{for } i = 1 \text{ to } n$$

$$I_i \ge 0 \quad \text{for } i=1 \text{ to } n$$

	I_1	I_2	I_3	I_4	D_1	D_2	D_3	D_4	D_5	
MAX	86	78	71	40	0	0	0	0	0	
ST.	1				-1					≤ 0
		3				-1	-1		-1	≤ 0
			3			-1	-1	-1		≤ 0
				2		-1	-1			≤ 0
					27	20	21	14	21	≤ 55
	1									
		1								≥ 0
			1							≥ 0
				1						≥ 0
					1					≥ 0
						1				≥ 0
							1			≥ 0
								1		≥ 0
									1	≥ 0

Figure 5.1: Integer Programming Application

As the objective function indicates, marginal information values for the representative Missouri River Basin water resource decision participant are expressed in thousand dollar increments. In keeping with the public goods nature of the information, to be strictly correct, each of these representative compensating surplus values should be multiplied by the number of users which the data base serves to obtain total marginal benefits for each information item. However, when all data interpretation and analysis costs are assumed to be minimal, omitting this step will not result in a change of the optimal solution. In situations where interpretation and analysis costs are not minimal, these costs would be deducted from the total user value of the indicated information item. Constraints one through four represent the production linkages between water data and water resource information items. Because these constraints must remain less than or equal to zero, they allow a particular water data item to enter the solution without requiring that an associated information item be produced. Conversely, when a particular information item enters the

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$D_k \geq 0$ for k=1 to p

where:

B_i = total user benefits for information item i;
A_i = total data analysis costs for I_i;
I_i = information item i; D_k = data item k;
L_{ik} = 1 if D_k is required for I_i; 0 otherwise;
m_i = number of data items required for I_i.

basis, the data items essential to its production must also enter the basis. The fifth constraint specifies the collection cost for each of the proposed water data items and requires that the total spent on water data not exceed \$55,000. A key feature of the model is that, because data are not consumed in the production of specific information items, once collected, a particular data item can be used to produce numerous water resource information items. Accordingly, collection costs for water data items are incurred but once. The remaining nonnegativity constraints are standard and simply serve to rule out the possibility of negative levels of data or information.

Casual consideration of the cost of data and the benefits of information presented in Table 5.1 might lead one to conclude that marginal data collection efforts should begin by collecting data necessary for the most highly valued information item. In the present example this would imply making the commitment to collect D_1 at a cost of \$27,000 resulting in the production of I_1 having a representative user value of \$86,000. Again, because D_6 is already being collected, its cost is external to the agency's benefit-cost calculus. Given sufficient alternatives, this approach would presumably continue until the available budget of \$55,000 was exhausted. However, in contrast to what casual impressions might suggest, integer programming results show that this type of approach will not in general result in the optimal data collection strategy. In addition to the importance of information item values, the capacity of water data to produce a broad range of water resource information items is equally important in determining the optimal data system. This observation is supported by the optimal solution to the example in which data items D_2, D_3, and D_4 are selected. These data exhaust the budget constraint, enabling the production of information items I_3 and I_4 for a total representative user value of $111,000. Given a budget constraint of $55,000, no other combination of data items could result in a greater information value. Thus, in this instance, the most highly valued information item, I_1, is not produced while the two lowest valued items, I_3 and I_4, are produced. In part this is due to the limited number of available alternatives in the example. However, from the data system design standpoint, a more important contributor to this outcome is that D_1, while only slightly more costly to collect than the other proposed data items, is highly specialized in that it leads only to the production of I_1. D_2 and D_3, on the other hand, contribute to the production of I_2, I_3, and I_4. If the budget constraint is relaxed somewhat, D_1 will enter the optimal solution, implying that

I_1 will be produced. However, as the budget constraint is further relaxed, D_1 is withdrawn from the optimal solution so that the greatest use of D_2 and D_3 can be made. Since, D_2 and D_3 have already entered the solution and their one-time costs of collection incurred, production of I_2 and I_3 merely involves incurring the collection costs of D_5 and D_4 respectively.

5.3 *CONCLUSION*

While the foregoing discussion is most directly oriented toward considerations regarding the marginal expansion of water data systems, the model is also capable of suggesting factors relevant to the reduction of data collection activities. Given the conditions which characterize the current budgetary environment, these insights may be of greater immediate value. If it is assumed that all the information and data items in the foregoing example comprise a water data-information system (equivalent to a data collection budget of $103,000 or more), it is possible to observe movements in the optimal solution as the data collection budget is decreased. Initially, as one might expect, a decrease in the budget allocated for data collection results in the discontinuance of one water data item at the margin. However, because the objective of the model is to maximize the value of the water information producible from the data, further budgetary reductions result in the elimination of some water data items so that previously discontinued data collection may be resumed. Again, this to some extent results from the limited number of alternatives in the chosen example. However, as before, a significant portion of what is observed is related to the capability of certain water data to support a broad range of water resource information items. While this data may produce, on average, lower valued information, the fact that it contributes to the production of many information products suggests that this type of basic data should be the last to be discontinued during periods of financial austerity.

Chapter VI

SUMMARY AND IMPLICATIONS

6.1 *SUMMARY*

At present, more than thirty different Federal agencies participate in the collection of water resources data. Among other things, these data are designed to characterize available supplies, rates of use, and quality aspects of surface and ground waters located either within state boundaries or river basin sub-units. Taken together, the efforts of these organizations have resulted in what has been called the National Water Data Network (Langford and Kapinos, 1979).

Justification for the commitment of scarce resources to water data collection rests primarily upon the fact that water data are of value in producing water resources information through analysis and interpretation. This information is used primarily by water resource decision participants located in water management organizations for resource monitoring, problem solving, and for the symbolic services which information provides in organizational settings. Viewed in this way, individuals acquire demands for water resource information as a result of their involvement in the organizational decision making process. Any attempt to understand this demand must recognize not only the effects of personal characteristics on information tastes and preferences, but must also be cognizant of the special role which differing organizational environments play in influencing information demand.

Recently, increasing attention has been focused upon water resource data collection activities, especially within those governmental agencies which have responsibilities for such activities. This interest has come about primarily as a result of growing concern over the potentially adverse effects of declining appropriations for water data collection associated with Federal deficit reduction measures. Facing the prospect of shrinking funds, water data collection agencies have begun to consider means of limiting or forestalling the effects which budget reductions might have on their ability to collect relevant data. Preliminary efforts have focused upon ways of reducing the costs associated with current collection programs. While the importance of improving technical efficiency cannot be disputed and constitutes a logical first step, concerns over budget reductions have evoked interest in the larger question of allocative efficiency in water data collection programs. If limited collection funds are being allocated inefficiently across data collection possibilities, the potential exists for altering collection plans to increase the value of data systems for the same level of expenditure. Although this fact is more obvious to data system planners during periods of budgetary austerity because of decisions related to discontinuance of some data items, factors relevant to improving and assessing allocative efficiency may be of interest regardless of levels of funding. While the considerations for improving allocative efficiency in data collection appear straightforward (adjust spending across data items until the value of the data system is maximized), in application questions immediately arise concerning what sort of values are to count, whose values are to count, and how will values be assessed. Because such considerations have historically been the province of the economics discipline, attention naturally focuses upon the extent to which economic theory can suggest principles applicable to the design of water data systems, and recommendations for water management agencies in mitigating the impacts of declining data collection appropriations.

The area of economics most directly related to these concepts is the economics of information. However, the economics of information has addressed public data and information systems only to a very limited extent. For a number of reasons the economics of information, as it has developed over the past few decades, is not well suited to the analysis of information demand arising within complex organizational settings. In the first instance, the economics of information literature and the closely related literature dealing with hydrologic network design have typically made no distinction between data and information. Second, while the theoretical arguments advanced by the economics of information literature would appear to offer guiding principles for the design of water data systems, techniques to apply these principles, in other than extremely simple situations, are lacking. Most importantly, the economics of information has overwhelmingly chosen to define information as an input to a decision production process. This orientation has limited the concept of information value entirely to its marginal product in decision *outcomes*. Despite the fact that the marginal product of information in producing a decision and the value of that decision are difficult or impossible to determine in policy contexts, the theory dealing with decision making in organizations suggests that information also is of value in the *process* of decision making. As a result of the deficiencies of the economics of information in accommodating the demand for information generated by organizational decision making, this study has sought to test a conceptual framework which extends the economic theory of information to include some observations which emerge from the literature concerning organizational decision processes.[18] Expressed as a general information demand model, this framework considers the nature of the demand and value for water resource information by individuals who participate in the decision making process found within public water management organizations. Demand for water resource information by its primary users is assumed to be dependent upon characteristics of the information, characteristics of the individual, and characteristics of the individual's organizational environment. The demands which water resource decision participants hold for information will affect the design of data systems.

> Because of the lack of prescribed objectives from high authority, one seeks guidance from the principle that the data programs must serve users. The relationship is clear with respect to the captive network, the data network established and operated by the user, such as that laid out for a research project. The relationship is not clear with respect to the general purpose network, where the collectors are not identical with the users (Langbein, 1979).

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[18] If entirely adopted, the observations provided by the organizational theory literature might imply that active data system design is unnecessary since, given sufficient time, a data system which minimizes inter-user conflict will emerge. However, since organizational performance and perception of goals is continually undergoing change, active planning will have a place in determining data system content. Moreover, the principles of opportunity cost and marginalism which active design employs are the same principles which ultimately drive organizational choice.

Based upon this general demand model, three empirical applications were considered in two separate water basin management situations; instream versus offstream water use competition in the Missouri River basin, and low freshwater inflows to Chesapeake Bay. The first application of the general information demand model was structured as a qualitative choice logit analysis of prior use or nonuse of the Second National Water Assessment by surveyed water resource decision participants. Through this analysis the effects of changes in personal and organizational characteristics on probability of Assessment use were estimated. Determination of the individual's use or nonuse of the Second National Water Assessment was accomplished by response to a direct question.

The second application stressing organizational theory themes focused upon hypothetical expenditures on "assessment information" items by the same water resource decision participants. Here, respondents were requested to assume that they were responsible for analyzing a particular water management problem and for making appropriate policy recommendations. Each respondent was presented with a list of available information items and respective costs. Subject to a budget limitation each respondent was asked to select his most preferred information system.

The third application of the general information demand model was an estimation of Hicksian compensating surplus values for a limited number of water resource information items through the contingent ranking nonmarket valuation method. For this application each respondent was again asked to assume that he was responsible for analyzing the same water management problem and for making policy recommendations. Five information packages were presented and based on the costs of the packages and their relative utility, each respondent was asked to rank the packages from most to least preferred.

Results of the first two analyses were consistent with the conceptual model which suggests that personal characteristics and the characteristics of an individual's organizational environment influence demand for certain types of water resource information. From a scientific research standpoint, the performance of the models was statistically acceptable and supports the derivation of general conclusions regarding information demand. However, it is not clear whether the performance of the models would be sufficient to support actual policy or investment decisions. This determination must ultimately be made by those involved in the policy process for specific policy situations. In comparing the performance of the first two applications in the water basin management contexts, the results (explanatory power and agreement with *a priori* expectations) of the Second National Water Assessment use/nonuse analyses were relatively superior to those of the "assessment information" expenditure analyses. Additionally, the results of the Missouri River basin expenditure analysis were marginally better than those of the Chesapeake Bay expenditure analysis. Two interrelated contributing factors were proposed to account for this outcome. Water resource decision participants located in the Missouri River basin, on the basis of a long history of regional involvement in managing water scarcity, were judged to have a higher level of sophistication in considering water resource issues and water resource information than their counterparts located in the Chesapeake Bay drainage area. This judgment was supported through the Chesapeake Bay drainage survey experience. In contrast to the Missouri River basin response rate of 75 percent, a much lower response rate of 51 percent was realized for the Chesapeake Bay drainage. Numerous questions were received from Chesapeake Bay respondents reflecting suspicion over the motives of the survey, its confidentiality, and the insignificance of the management focus of the questionnaire. In addition, substantial numbers of questionnaires were passed from their intended recipient to other individual's within organizations. The judgment of greater sophistication on the part of the Missouri River basin survey respondents coupled with the hypothetical nature of the "assessment information" expenditure situation posed in the questionnaire, was believed to account for why assessment use/nonuse results were better than the expenditure model results and why expenditure results in the Missouri River basin were superior to those observed in the Chesapeake Bay drainage. Despite these varying degrees of success, each analysis indicated that organizational characteristics were significant in affecting the demand for water resource information.

The third application of the general information demand model, the contingent ranking analysis was undertaken to demonstrate how information values could be estimated as a result of the consumer demand orientation of the study's conceptual framework, and how such values could be used to aid data system design. Based upon individual responses made in the contingent ranking situation posed in the questionnaires, random utility functions were estimated for both river basin management contexts. Interpreting these functions as approximations to representative indirect utility functions, compensating surplus measures were estimated for a limited number of marginal water resource information items. Estimation of these values was intended to be more illustrative than definitive since the validity of such values depends on the relative magnitudes of actual information package costs. In the contingent ranking situation posed in both surveys, information package costs were established relative to an assumed baseline package cost of $100,000. Differences in cost between the baseline package and nonbaseline packages reflected the incremental costs of an additional information item. For the most part, these incremental costs were selected to be consistent with the costs of information items in the "assessment information" expenditure situation where such costs were largely assumed.

As in the analyses of expenditures on assessment information, results from the Missouri River basin contingent ranking analysis were superior to those obtained in the Chesapeake Bay analysis. Again, the same general factors proposed in the former analyses were presumed to largely account for this outcome.

Using the marginal information values estimated in the Missouri River basin contingent ranking analysis, a problem in data system design was illustrated within an integer programming framework. In that framework, data item costs, production relationships between data items and information items, and knowledge concerning information item values were linked to select those data items resulting in the most highly valued information set relative to an overall budget constraint. By tightening and relaxing the budget constraint, conclusions for data system design based upon the value of information to users were drawn.

6.2 *IMPLICATIONS*

From the theoretical investigations and empirical applications undertaken in this study, a number of relevant implications can be drawn. For the most part, these implications relate to two primary themes; implications for research in the economics of information, and implications for water data system design.

6.2.1

Based upon the results obtained in the Second National Water Assessment use analyses and the expenditure analyses concerning "assessment information", it is clear that in choice situations occurring in organizational settings, an individual's demand for information will be affected by relevant personal characteristics and characteristics of his organizational environment. Even when confronted with identical water management issues and identical informational possibilities, different individual's are observed to exhibit different information priorities. *Therefore, there can exist no generally agreed upon water information system for any given water resource issue or set of issues, and thus no intrinsically correct data collection program.* Search for the "ideal" water data system, based upon such criteria as complete description of the hydrologic cycle, will be frustrated. *Data system design must instead be based on knowledge of who the data system is to serve, and relative information demands.*

6.2.2

Because it could be argued that in business and in public policy most decisions are the result of organizational decision processes, failure to account for the effects of organizational determinants represents a serious omission in any theory of information demand. To this point, the economic theory of information has not recognized this fact. The demand and value of information has been directly tied to the role of information in decision outcomes. Information demand has been viewed as a derived demand for a factor of production. As a result of this outlook, the economics of information has been limited primarily to applications involving relatively simple situations involving information acquisition by individuals involved in some production related activity. The economics of information can advance beyond such simple situations to provide something more useful than efficiency conditions which are difficult, if not impossible, to apply in actual situations of data or information acquisition. To do this, *the economics of information must begin to explicitly consider the demand for information as it results from organizational choice, and the nontechnical value which information provides in the organizational decision process*. One approach for incorporating such considerations into economics of information theory is to view information demand not as demand for a factor of production, but in a manner analogous to a consumer commodity. However, the type of consumer demand suggested is not of the conventional type in which consumption of a good or service provides direct *personal* utility to an individual. Instead, consumption of the information commodity by water resource decision participants could be said to provide *professional* utility. The result of the use of certain items of information is to improve the organizational decision process and to provide for the continuity of organizational decision making capability. *Consequently, the value of information should be based upon its decision support value which would include not only value related to decision outcome, but also value realized in decision process*.

6.2.3

Until quite recently, no distinction was made in the economics of information literature between data and information. By treating data and information as synonymous, considerable confusion can be generated with regard to strategies for data system design. In the absence of this distinction, it is easy to conclude that information items with the largest value should be provided first until budgets are exhausted. However, as indicated in the previous chapter, when the distinction and interrelationship between data and information are understood, it becomes clear that this strategy will not in general lead to maximum information system value. Additionally, confusion over the distinction between data and information has led to incorrect conclusions regarding the ability of users to contribute to the design of water data systems. Langbein (1979) for example has noted that, "Meetings and conferences among data collectors and representative data users have long been part of the national scene, but these have their limits as a sufficient tool in designing a network, largely . . . because users are not in fact always sufficiently perceptive to identify actual and prospective needs. They emphasize their *ad hoc* purposes, whereas data may serve many repeated diverse uses over time." Consequently he concludes, "Usually, the most searching critique about the use of data originates with those who collect them." This conclusion illustrates a failure to recognize the different roles which data and information play in complex organizational decision processes. In most instances, there is no direct demand for data by decision makers. They demand information. *Consequently, those seeking user input for system design pose an incorrect question when they ask what data should be collected. Consideration of the relationship between data and information and organizational decision theory implies that a more correct and meaningful question would be to ask decision makers what their information demands are, and based upon their responses interpret what data would be required to produce that information.*

6.2.4

While the economics of information has provided little in the way of specific methods or techniques to assist water data system design, it would be incorrect to conclude from this discussion that conventional economic theory is of no value in assisting data system planners. As an area of interest within the larger economic discipline, the economics of information is privy to the propositions which have emerged from the study of economic phenomena over the past 200 years. While these concepts are general in nature and appear obvious to the economist, "in so far as economic theory is useful in enabling us to understand the real world and in helping us to make decisions on policy, it is the simple, most elementary and, in some ways, the most obvious propositions that matter (Devons, 1961, p. 13-14.)". Moreover, Robbins has argued that

> the most useful economic principles, when stated in their most general form, seem often mere banalities, almost an anti-climax after the formidable controversies amid which they have emerged. Yet experience seems to show that, without systematic training in the application of such platitudes the most acute minds are liable to go astray (1971, p. 203).

While the economics of information may lack a precise formal model to use in selecting a data system, economics can make a contribution to assessing data systems and information systems. It can do this by reinforcing consideration of a number of economic principles including general observations of decreasing marginal returns and increasing marginal costs, interaction of supply and demand, the concept of opportunity cost, and marginalism.

Like most other commodities, information is expected to exhibit decreasing marginal returns and increasing marginal costs. What this means to those who demand water resource information is that *it does not make sense to attempt to eliminate all uncertainty, be it uncertainty over resource endowments or uncertainty over consequences of policy alternatives. Beyond a certain point, the opportunity costs of acquiring more information exceed the benefits.*

Consideration of the economic concept of the interaction of supply and demand implies that *data system design, as opposed to a one time process, is likely to be a continuing process.* As demand and value for different information items change, as they surely will as a result of changes in theory, changes in phenomenon, and changes in the agenda of relevant issues, data system design based to some degree upon user demand will respond by supplying appropriate data for meeting emerging information demands. Noneconomists typically see the design of water data systems as a one time process guided by criteria such as complete description of the hydrologic cycle. Consequently, the content of the data system is never questioned and never undergoes revision. Such an approach produces a high level of stability in data collection plan and a large degree of predictability. Unlike some data systems however, because of the physical basis typifying most water management issues, a significant core of data relating hydrologic conditions will likely always remain an integral part of any water data system. Thus the extent of redesign required for water data systems would be expected to be less than that for many other systems.

According to the economic concept of opportunity cost, the cost of pursuing any particular alternative is equal not only to the direct costs associated with that alternative but also the benefits associated with foregone alternatives. This concept is especially critical to data system design as demonstrated in the integer programming application presented in the previous chapter. In the presence of limited data collection budgets, the decision to collect a particular water data item may result in the inability to provide for the production of many different types of information. Accordingly, *the cost associated with the decision to collect a particular water data item is equal not only to its direct cost of collection, but also the ultimate benefits of foregone information resulting from data which is excluded from the data system.* Seen in this way, maximizing the value of water resource information producible from a water data system is equivalent to minimizing the sum of the data system's opportunity cost. Data system design must proceed by recognizing the opportunity costs imposed by current collection strategies.

Closely related to the concept of opportunity cost is the marginal theory of value which plays such a large role in economic theory. In its most basic form, the marginal theory of value suggests that, instead of being concerned with average values and average costs, the more relevant concern is what is occurring at the margin. If the goal is to maximize, activity should be discontinued when benefits at the margin fall below marginal costs. When commodities are finely divisible, conventional efficiency conditions, whether in consumption or production, state that marginal benefits should be equated to marginal costs. However, in this study it has been argued that information and data are fundamentally "lumpy". Consequently, in maximizing the value of water information producible from a water data system, it would be observed that marginal benefits of information will remain unequal. In the largest sense, marginal value theory is directed toward improving efficiency of resource allocation. *To the extent that data system planners attempt to increase their understanding of the role which different types of data play in producing different types of water resource information and the value of that information to water resource decision participants, the objective behind the concept of marginal analysis will be met.*

6.2.5

In considering the design of data systems, Peskin and David (1984) have concluded that, in order to improve efficiency, increasing attention must be paid to how different types of information affect goals. In essence they propose doing a better job of assessing the marginal product of information and the value of decision outcomes; a traditional economics of information limited production approach to information. This study has argued that this approach to data system design is not practical since the role of information in producing a particular decision and the value of that decision are unknowable in policy contexts. Accordingly, this study has proposed an alternative approach to water data system design which is based upon an analysis of the value of water resources information to individuals involved in the organizational decision processes found within public water resource management agencies. As a method for eliciting these values, the nonmarket valuation technique of contingent ranking was proposed and tested. Considering the results of the contingent ranking analyses, the recommendation concerning the potential of this technique for information value estimation is mixed. Based upon the results of the Missouri River basin analysis, prospects for the continued use of contingent ranking appear favorable. Along with the hypothetical expenditure situation, the consistently plausible signs and magnitudes for the explanatory variables suggest that respondents perceived the survey structure as realistic and did not experience difficulties with the hypothetical nature of the questions. In the Chesapeake Bay analysis, however, much the opposite was true. *These results would suggest that further examination of the* *potential for use of contingent ranking in estimating information value is warranted.* However, even in the absence of information values determined through technical nonmarket valuation techniques, data system design as framed in this study may proceed through the use of less sophisticated, but perhaps less hypothetically restricting, indicators of relative information values. Water resource decision participants could be asked, for example, to indicate their relative weightings for different water information items. With these weights, determination of data system content could proceed in a manner analogous to the integer programming example presented in the previous Chapter. Whether Hicksian compensating surplus values or subjective relative weights are used to represent information value, the framework makes clear that, in addition to the value of a particular item of information, the costs of data collection and analysis and the opportunity cost of foregone information production capability are equally important in determining data system design.

The potential applicability and usefulness of the contingent ranking approach adapted to the valuation of information will ultimately have to be made by those involved in water data collection activities. Regardless of their decision, *the general implication that data system design* *must be based on a clear understanding of who the data system exists to serve and their informational demands, cannot be overlooked.* The analysis has shown that different individuals place different priorities on information. Since budgets are seldom unlimited, choices will have to be made regarding which information demands will be met and which will be overlooked. Data collected to provide information for federal decision making may not serve the decision process at the state level. Data collected to provide information for economists may not serve the demands of hydrologists. *To the extent that those involved in data collection planning are unwilling or unable to establish their clientele, they will reside in a continuing state of uncertainty regarding what they should collect.* This observation applies not only to small single purpose data systems, but also large multi-purpose water data systems. Large multi-purpose systems may establish their primary clientele as decision makers in federal water management agencies. Clearly this takes in a wide range of organizational missions (e.g., developmental, regulatory, scientific), and a wide range of individuals. Consequently, such systems will never please everybody and will most likely displease most. However, this does not imply that such systems should be discontinued in deference to many smaller single purpose data systems.

6.2.6

From the conclusions drawn from the data system design example presented in the last Chapter, during periods of budgetary austerity, water data systems should concentrate on preserving the types of basic data which are of value in producing many different types of water resource information. To a large extent this includes basic hydrologic monitoring data. This does not imply that financial resources should be equally distributed across all aspects of the hydrologic cycle, or even that all aspects of the hydrologic cycle should even be included in a data collection strategy.

6.2.7

Data system design should concentrate on users and information. Past efforts to set priorities have typically concentrated on the data itself in the expectation that there is some universally defined "optimal" data system. Instead, the implication of this study is that management of water data systems must first focus upon determining clientele, and information demands. Because different individuals in different organizational settings have different information demands, determination of whose interests will be served and whose will not, will clearly affect the contents of any particular data system. Therefore, whom the data system is designed to serve is an important question data collection agencies should address first. Following this, attention can then turn toward determining cost effective data system designs to meet those demands. While it may not be possible, or even desirable given the costs, to find and implement the optimal data system design, not all feasible designs are equally good. Efficiency of resource use is a matter of degree and consideration of the value of different types of water information to users can assist data collection agencies in improving the design of their data systems.

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Appendix A

SURVEY CORRESPONDENCE

A LAND-GRANT UNIVERSITY

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Blacksburg, Virginia 24061

Department of Agricultural Economics

August 29, 1985

John Doe
1234 Anystreet
Missouri River, USA 99999

Dear Mr. Doe:

Recently, increasing attention has been focused upon public water resource data and information systems. Faced with the prospect of declining budget allocations, water data collection agencies such as the U.S. Geological Survey are seeking ways to insure that public water data and information systems are serving the needs of water resource decision makers.

As a user of water resources information, you are among a small number of individuals being asked to participate in this study. Your cooperation will contribute to the continuing efforts of the U.S. Geological Survey to provide relevant water resource data and information. The results of this study will accurately represent the thinking of water resources information users in the Missouri River basin only if you complete and return the enclosed questionaire. It is important that the responses reflect <u>your</u> opinions. Thus, we would prefer that you not confer with others about your responses or entrust the completion of this questionnaire to someone else. If you find it necessary to have another person complete the questionnaire, the responses should reflect his/her own opinions and situation.

You may be assured of complete confidentiality. The questionnaire has an identification number for mailing purposes only. This is so that we may check your name off of the mailing list when your questionnaire is returned. Your name will never be placed on the questionnaire. For your convenience, a postage-paid return envelope has been enclosed.

I would be most happy to answer any questions you might have. Please write, or call collect at . Thank you for your assistance.

Sincerely,

Tim Osborn
Research Associate

dmc

A LAND-GRANT UNIVERSITY

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Blacksburg, Virginia 24061

Department of Agricultural Economics

August 29, 1985

John Doe
Director
State or Federal Agency
1000 Anystreet
Missouri River, USA 99999

Dear Mr. Doe:

Recently, increasing attention has been focused upon public water resource data and information systems. Faced with the prospect of declining budget allocations, water data collection agencies such as the U.S. Geological Survey are seeking ways to insure that public water data and information systems are serving the needs of water resource decision makers.

We of the Department of Agricultural Economics at Virginia Tech are presently conducting a survey as part of a study requested by the Water Resources Division of the U. S. Geological Survey. This survey, which is being directed to water resource information users and decision makers in the Missouri River basin, is part of an effort to assess water data needs and to test new methods of data system design. We are contacting you to enlist your cooperation in the successful completion of this survey. Enclosed you will find two (2) questionnaires with accompanying cover letters and postage-paid return envelopes. Please present these to two individuals in your organization who are involved in upper-level water resource decision making. It is not necessary that these individuals have experience with water data collection or data system design. Please feel free to answer one of the questionnaires yourself, if you desire. We estimate that the questionnaire requires 20 minutes or less to complete.

You may be assured of complete confidentiality. The questionnaire has an identification number for mailing purposes only. This is so that we may account for the enclosed questionnaires when they are returned. Names will never be placed on the questionnaire.

I would be most happy to answer any questions you might have. Please write, or call collect at . Thank you for your assistance.

Sincerely,

Tim Osborn
Research Associate

dmc

COLLEGE OF AGRICULTURE AND LIFE SCIENCES

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Blacksburg, Virginia 24061

DEPARTMENT OF AGRICULTURAL ECONOMICS

August 29, 1985

Recently, increasing attention has been focused upon public water resource data and information systems. Faced with the prospect of declining budget allocations, water data collection agencies such as the U.S. Geological Survey are seeking ways to insure that public water data and information systems are serving the needs of water resource decision makers.

As a user of water resources information, you are among a small number of individuals being asked to participate in this study. Your cooperation will contribute to the continuing efforts of the U.S. Geological Survey to provide relevant water resource data and information. The results of this study will accurately represent the thinking of water resources information users in the Missouri River basin only if you complete and return the enclosed questionnaire. It is important that the responses reflect <u>your</u> opinions. Thus, we would prefer that you not confer with other about your responses or entrust the completion of this questionnaire to someone else.

You may be assured of complete confidentiality. The questionnaire has an identification number for mailing purposes only. This is so that we may account for which questionnaires have or have not been returned. Your name will never be placed on the questionnarie. For your convenience, a postage-paid return envelope has been enclosed.

I would be most happy to answer any questions you might have. Please write, or call collect at . Thank you for your assistance.

Sincerely,

Tim Osborn
Research Associate

Last week a questionnaire seeking your opinions about water resource data and information was mailed to you.

If you have already completed and returned it to us please accept our sincere thanks. If not, please do so today in order to make your opinion count in the survey's results.

If by some chance you did not receive the questionnaire,or if it was misplaced, please call me collect so that I may place another in the mail for you today.

Sincerely,

Tim Osborn

A LAND-GRANT UNIVERSITY

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Blacksburg, Virginia 24061

Department of Agricultural Economics

September 24, 1985

John Doe
1000 Anystreet
Missouri River, USA

Dear Mr. Doe:

Approximately three weeks ago I wrote to you seeking your opinions about water resources data and information. As of today, I have not yet received your completed questionnaire.

We in the Department of Agricultural Economics at Virginia Tech are presently conducting this survey as part of a study requested by the Water Resources Division of the U.S. Geological Survey. This survey, which has been sent to a sample of water resources information users in the Missouri River basin, is part of an effort to assess water data needs and to test new methods of data system design. While we are encouraged by the number returned thus far, in order for the study to truly represent the opinions of all Missouri River basin water information users it is essential that each person who received a questionnaire complete and return it to us.

In the event that your questionnaire has been misplaced, or if you never received one, another has been enclosed.

Your cooperation is greatly appreciated. I would be most happy to answer any questions you might have. Please write, or call collect at . Thank you for your assistance.

Cordially,

Tim Osborn
Research Associate

dmc

A LAND-GRANT UNIVERSITY

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Blacksburg, Virginia 24061

Department of Agricultural Economics

January 23, 1986

Mr. John Doe
Water Resource Decision Maker
1000 Anystreet
Chesapeake Bay, USA

Dear Mr. Doe:

Recently, increasing attention has been focused upon public water resource data and information systems. Faced with the prospect of declining budget allocations, water data collection agencies such as the U.S. Geological Survey are seeking ways to insure that public water data and information systems are serving the needs of water resource decision makers.

We in the Department of Agricultural Economics at Virginia Tech are presently conducting surveys in several regions of the United States as part of a study requested by the Water Resources Division of the U.S. Geological Survey. The enclosed questionnaire is being directed to water resource information users and decision makers like yourself who have an interest in the Chesapeake Bay drainage area. Its primary intent is to assess water data needs and to test new methods of data system design. The results of this study will accurately represent the thinking of Chesapeake Bay region water resource information users only if you complete and return the enclosed questionaire. It is important that the responses reflect your opinions. Thus, we would prefer that you not confer with others about your responses or entrust the completion of this questionnaire to someone else. If you find it necessary to have another person complete the questionnaire, the responses should reflect his/her own opinions and situation.

You may be assured of complete confidentiality. The questionnaire has an identification number for mailing purposes only. This is so that we may check your name off of the mailing list when your questionnaire is returned. Your name will never be placed on the questionnaire. For your convenience, a postage-paid return envelope has been enclosed.

Based upon experience with similar surveys we have found that the questionnaire requires less than 20 minutes to complete. I would be most happy to answer any questions you might have. Please write, or call collect at . Thank you for your assistance.

Sincerely,

Tim Osborn
Research Associate

dmc

A LAND-GRANT UNIVERSITY

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Blacksburg, Virginia 24061

Department of Agricultural Economics

January 23, 1986

Mr. John Doe
Director, Water Agency
1000 Anystreet
Chesapeake Bay, USA

Dear Mr. Doe:

Recently, increasing attention has been focused upon public water resource data and information systems. Faced with the prospect of declining budget allocations, public water data collection agencies are seeking ways to insure that water data and information systems are serving the needs of water resource decision makers.

We in the Department of Agricultural Economics at Virginia Tech are presently conducting surveys in several regions of the United States as part of a study requested by the Water Resources Division of the U.S. Geological Survey. The enclosed survey, which is being directed to water resource information users and decision makers having interest in the Chesapeake Bay drainage area, is part of an effort to assess water data needs and to test new methods of data system design. We are contacting you to enlist your cooperation in the successful completion of this survey. Enclosed you will find two (2) questionnaires with accompanying cover letters and postage-paid return envelopes. Please present these to two individuals in your organization who are involved in upper-level water resource decision making. It is <u>not</u> necessary that these individuals have experience with water data collection or data system design. Please feel free to answer one of the questionnaires yourself, if you desire. Based upon experience with other surveys we have found that the questionnaire requires less than 20 minutes to complete.

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I would be most happy to answer any questions you might have. Please write, or call collect at . Thank you for your assistance.

Sincerely,

Tim Osborn
Research Associate

dmc

COLLEGE OF AGRICULTURE AND LIFE SCIENCES

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Blacksburg, Virginia 24061

DEPARTMENT OF AGRICULTURAL ECONOMICS

January 23, 1986

Recently, increasing attention has been focused upon public water resource data and information systems. Faced with the prospect of declining budget allocations, public water data collection agencies are seeking ways to insure that public water data and information systems are serving the needs of water resource decision makers.

As a user of water resources information, you are among a small number of individuals being asked to participate in this survey. Your cooperation will contribute to the continuing efforts of the U.S. Geological Survey to provide relevant water resource data and information. The results of this survey will accurately represent the thinking of water resource information users involved in Chesapeake Bay Basin issues only if you complete and return the attached questionnaire. It is important that the responses reflect your opinions. Thus, we would prefer that you not confer with others about your responses or entrust the completion of this questionnaire to someone else.

You may be assured of complete confidentiality. The questionnaire has an identification number for mailing purposes only. This is so that we may account for which questionnaires have or have not been returned. Your name will never be placed on the questionnaire. For your convenience a postage-paid return envelope has been enclosed.

I would be most happy to answer any questions you might have. Please write, or call collect at . Thank you for your assistance.

Sincerely,

Tim Osborn
Research Associate

syd

Last week two questionnaires seeking the opinions of two upper level water resource decision makers in your organization about water resource data and information were mailed to you.

If these have been completed and returned please accept our sincere thanks. If not, please take steps to see that they are promptly completed and returned so that the perspectives of your organization are included in the survey's results.

If by some chance you did not receive the questionaires, or if they were misplaced, please call me collect so that I may place others in the mail for you today.

Sincerely,

Tim Osborn

A LAND-GRANT UNIVERSITY

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Blacksburg, Virginia 24061

Department of Agricultural Economics

February 26, 1986

Mr. John Doe
Water Resource Decision Maker
1000 Anystreet
Chesapeake Bay, USA

Dear Mr. Doe:

Several weeks ago I wrote to you seeking your assistance in the completion of two "Water-Data Needs" questionnaires. As of today, our records indicate that we have not received either questionnaire. If the questionnaires have been recently mailed or if you have previously contacted us please accept our sincere thanks.

We in the Department of Agricultural Economics at Virginia Tech are presently conducting a survey as part of a study requested by the Water Resources Division of the U.S. Geological Survey. This survey which has been sent to a sample of water resources information users is part of an effort to assess water data needs and to test new methods of data system design. While we are encouraged by the number returned thus far, in order for the study to truly represent the opinions of a wide range of water resource information users and decision makers, it is essential that each person who received a questionnaire complete and return it to us. In the event that the questionnaires were misplaced, or if you never received any, two others have been enclosed. If you have not already done so, please present these to two individuals in your organization who are involved in upper-level water resource decision making. It is not necessary that these individuals have experience with water data collection or data system design. Please feel free to answer one of the questionnaires yourself, if you desire. Based upon experience with other surveys we have found that the questionnaire requires less than 20 minutes to complete.

Your cooperation is greatly appreciated. I would be most happy to answer any questions you might have. Please write, or call collect at . Thank you for your assistance.

Cordially,

Tim Osborn
Research Associate

dmc

Appendix B

SURVEY QUESTIONNAIRES

Missouri River Basin Water-Data Needs Survey

This survey of water information users and decision makers in the Missouri River basin is part of a continuing U.S. Geological Survey effort to assess water data needs. Part I requests your opinions about the federal water data system. Part II, is unique from the rest of the survey. It asks you to participate in an effort to test new methods for public data system design. Part III requests a limited amount of information about you and your organization to permit us to interpret the survey responses.

The survey is being conducted by the Department of Agricultural Economics at Virginia Tech University as part of a study requested by the U.S. Geological Survey. Please answer all the questions. If you wish to comment on any of the questions use the space in the margins. Your comments will be read and taken into account.

Thank you for taking the time to help!

Part I

Presently, more than 30 different agencies of the Federal government collect some form of data concerning our nation's water resources.

Q-1 Have you personally used data from the "federal water data system" in performing your work related responsibilities? (Circle number)

1 YES ----- IF YES SKIP FROM HERE TO Q-3.
2 NO

(if no)
Q-2 Have other individuals in your organization made use of data contained in the "federal water data system"? (Circle number)

1 YES
2 NO ----- IF NO SKIP FROM HERE TO Q-4.

Q-3 In general, how satisfied are you and your organization with the content and accuracy of the "federal water data system"? (Circle one number in each column)

CONTENT	ACCURACY	
1	1	VERY SATISFIED
2	2	SATISFIED
3	3	NEITHER SATISFIED OR DISSATISFIED
4	4	DISSATISFIED
5	5	VERY DISSATISFIED

One direct product of the "federal water data system" has been the National Water Assessments of the U.S. Water Resources Council. The most recent, the Second National Assessment of 1978, sought to characterize the state of our water resources from a national perspective. At this time, the future of such Assessments, as they have traditionally been practiced, is uncertain.

Q-4 Have you made use of the Second National Water Assessment produced by the Water Resources Council? (Circle number)

1 YES
2 NO ----- IF NO SKIP FROM HERE TO Q-6

(if yes)
Q-5 In general, how satisfied aree you with the content and accuracy of the Second National Water Assessment? (Circle one number in each column)

CONTENT	ACCURACY	
1	1	VERY SATISFIED
2	2	SATISFIED
3	3	NEITHER SATISFIED OR DISSATISFIED
4	4	DISSATISFIED
5	5	VERY DISSATISFIED

Q-6 Despite you satisfaction or dissatisfaction with past National Assessments, do you feel that a periodic national appraisal of the nation's water resources situation is desirable? (Circle number)

1 YES
2 NO

Part II

Limited budgets require designers of public water data systems to choose what data to include in the system, and what to omit. In doing this, they try to include data having the greatest value to users. We would like to learn more about how users value different types of information and test some methods of data system design by making you the designer of your own hypothetical information system.

Q-7 The Second National Assessment by the U.S. Water Resources Council identified several water problems existing in the Missouri River basin. Of interest to many is the competition between instream water uses and off-stream uses over available water. Instream uses include navigation, hydro-power, fish and wildlife, and recreation. Off-stream uses include irrigation, industrial use, municipal use, and steam-electric generation. Assume that you are responsible for analyzing the problem of competing uses and for making policy recommendations. Also assume that no appropriate information exists.

Your organization has asked you to select <u>one</u> information package from the five alternatives on the facing page. This will be the only information you will be authorized to obtain. No budget limit has been set, but the cost of the information package will be deducted from the typical annual operating budget of your organization. Considering both costs and the usefulness of the information, rank the packages from most preferred to least preferred. (Write number of package in appropriate box)

☐ MOST PREFERRED ☐ 2ND MOST PREFERRED ☐ 3RD MOST PREFERRED

☐ 4TH MOST PREFERRED ☐ LEAST PREFERRED

PACKAGE 1: COST $100,000

* Estimates of current surface water supplies.
* Estimates of current surface water withdrawals.
* Estimates of current ground water supplies.
* Estimates of current ground water withdrawals.

PACKAGE 2: COST $150,000

* Estimates of current surface water supplies.
* Estimates of current surface water withdrawals.
* Estimates of current ground water supplies.
* Estimates of current ground water withdrawals.
* Estimates of the economic value of water in various instream and off-stream uses.

PACKAGE 3: COST $135,000

* Estimates of current surface water supplies.
* Estimates of current surface water withdrawals.
* Estimates of current ground water supplies.
* Estimates of current ground water withdrawals.
* Information describing the interrelationship between surface and groundwater.

PACKAGE 4: COST $110,000

* Estimates of current surface water supplies.
* Estimates of current surface water withdrawals.
* Estimates of current ground water supplies.
* Estimates of current ground water withdrawals.
* Forecasts of future water withdrawals by major uses.

PACKAGE 5: COST $125,000

* Estimates of current surface water supplies.
* Estimates of current surface water withdrawals.
* Estimates of current ground water supplies.
* Estimates of current ground water withdrawals.
* Relationship between water cost or price and quantity of water demanded.

Q-8 Again assume that you are responsible for analyzing the instream/off-stream use competition problem in the Missouri River basin. Assume that no appropriate information concerning this problem exists.

You are given a budget of $100,000 which may only be spent on information acquired from the following list. After reviewing all the selections and being careful not to exceed a total expenditure of $100,000, circle the numbers of the information items that you would include in your most preferred information system.

1 ESTIMATES OF CURRENT WITHDRAWALS BY MAJOR WATER USE FROM SEPARATE STREAMS IN THE MISSOURI RIVER BASIN (COST $15,000).

2 ESTIMATES OF CURRENT WITHDRAWALS BY MAJOR WATER USE WITHIN STATES AND WATER RESOURCE SUBREGIONS (COST $15,000)

3 HISTORICAL RECORD OF WITHDRAWALS BY MAJOR WATER USE FROM SEPARATE STREAMS IN THE MISSOURI RIVER BASIN (COST $10,000).

4 HISTORICAL RECORD OF WITHDRAWALS BY MAJOR WATER USE WITHIN STATES AND WATER RESOURCE SUBREGIONS (COST $10,000)

5 EFFECTS OF VARIOUS INSTREAM FLOW RATES ON FISH AND WILDLIFE POPULATIONS (COST $25,000).

6 RELATIONSHIP BETWEEN COST OR PRICE OF WATER AND MAJOR OFF-STREAM USE RATES (COST $25,000).

7 INFORMATION DESCRIBING THE HYDROLOGIC INTERRELATIONSHIP OF GROUNDWATER AND SURFACE WATER (COST $30,000).

8 HISTORICAL ANALYSIS OF THE LEGAL EVOLUTION OF WATER RIGHTS IN THE MISSOURI RIVER BASIN (COST $10,000).

9 QUANTIFICATION OF INDIAN AND FEDERALLY RESERVED WATER RIGHTS IN THE MISSOURI RIVER BASIN (COST $20,000).

10 FORECASTS OF FUTURE WITHDRAWALS FOR MAJOR USES FOR SEPARATE STREAMS IN THE MISSOURI RIVER BASIN (COST $20,000).

11 FORECASTS OF FUTURE WITHDRAWALS FOR MAJOR USES WITHIN STATES AND WATER RESOURCE SUBREGIONS (COST $20,000).

12 ESTIMATES OF THE ECONOMIC VALUE OF WATER TO VARIOUS OFF STREAM USES (COST $25,000).

13 ESTIMATES OF THE ECONOMIC VALUE OF WATER FOR VARIOUS INSTREAM USES (COST $25,000).

14 ESTIMATES OF CURRENT SURFACE WATER SUPPLIES (COST $15,000).

15 ESTIMATES OF CURRENT GROUND WATER SUPPLIES (COST $20,000).

16 INFORMATION ON THE AVAILABILITY AND COSTS OF INTERBASIN WATER TRANSFERS (COST $15,000).

17 INFORMATION ON RELATIONSHIP BETWEEN WATER QUALITY AND INSTREAM FLOW (COST $15,000).

18 ESTIMATES OF GROUNDWATER QUALITY (COST $20,000).

Part III

Finally, we would like to ask some questions about you and your organization to help us interpret the results.

Q-9 Which best describes your current employment? (Circle number)

1 FEDERAL GOVERNMENT AGENCY
2 STATE GOVERNMENT AGENCY
3 REGIONAL GOVERNMENT AGENCY
4 LOCAL GOVERNMENT
5 PRIVATE INDUSTRY
6 UNIVERSITY
7 OTHER -PLEASE SPECIFY

IF YOU ANSWERED 5, 6, or 7 SKIP TO Q-11.

____

Q-10 Which best describes the mission orientation of your organization? (Circle number)

1 DEVELOPMENTAL
2 REGULATORY
3 SCIENTIFIC-INVESTIGATIVE
4 OTHER -PLEASE SPECIFY

____

Q-11 What is the name of the parent organization for which you work?

__________________________name

Q-12 For what division or branch of this organization do you work?

_________________________name

Q-13 What is your job title?

_________________________job title

Q-14 Where are you employed within this organization? (Circle number)

1 HOME OFFICE
2 FIELD OFFICE

Q-15 Approximately, what was your division or branch's most recent total annual operating budget for planning, agency operations, and research and development?

_______________dollars

Q-16 How long have you been employed by this organization?

_______________years

Q-17 What percent of your professional time is devoted to each of the following areas of responsibility?

(RESPONSIBILITY)	(PERCENT)
BUDGET ALLOCATION	________
RESEARCH AND DEVELOPMENT	________
PROGRAM PLANNING	________
AGENCY OPERATIONS	________
OTHER-PLEASE SPECIFY	
____________________	________
Total	100%

Q-18 How long have you been professionally active in water resource issues?

________________years

Q-19 What is the highest level of education that you have completed? (Circle number)

1 HIGH SCHOOL
2 SOME COLLEGE
3 FOUR YEAR COLLEGE DEGREE
4 SOME POST GRADUATE WORK
5 MASTER'S DEGREE
6 PH.D
7 OTHER -PLEASE SPECIFY

____

Q-20 Which of the following best describes the major subject area of your professional employment? (Circle one number)

1 ENGINEERING
2 HYDROLOGY
3 LAW
4 BIOLOGY-LIFE SCIENCES
5 GEOLOGY-EARTH SCIENCES
6 ECONOMICS
7 OTHER SOCIAL SCIENCES
8 PUBLIC ADMINISTRATION
9 OTHER -PLEASE SPECIFY

____

Is there any thing else you would like to tell us about public water data collection priorities, or about this questionaire? Please use this space for that purpose.

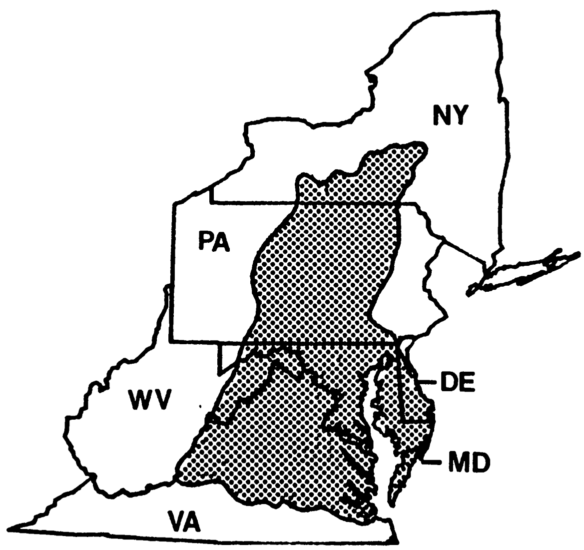
YOUR CONTRIBUTION TO THIS
EFFORT IS GREATLY APPRECIATED!

Department of Agricultural Economics
Virginia Tech University
Blacksburg, VA 24061

Chesapeake Bay Drainage Water-Data Needs Survey

This survey of water information users and decision makers in the Chesapeake Bay region is part of a larger effort to assess water data needs. Part I requests your opinions about water data systems. Part II, is unique from other surveys in that it asks you to participate in an situation to test new methods for public data system design. Part III requests a limited amount of information about you and your organization to permit us to interpret the survey responses.

The survey is being conducted by the Department of Agricultural Economics at Virginia Tech as part of a study requested by the U.S. Geological Survey. Please answer all the questions. If you wish to comment on any of the questions use the space in the margins. Your comments will be read and taken into account.



Thank you for taking the time to help!

Part I

Presently, more than 30 Federal Government agencies collect some type of water resources data. In the past one product of these efforts was the National Water Assessment of the U.S. Water Resources Council. The most recent, the Second National Assessment of 1978, sought to characterize the state of our water resources from a national perspective. At this time, the future of such Assessments, as they have traditionally been practiced, is uncertain.

Q-1 Have you made use of the Second National Water Assessment produced by the Water Resources Council? (Circle number)

1 YES
2 NO ----- IF NO SKIP FROM HERE TO Q-3

(if yes)
Q-2 In general, how satisfied are you with the content and accuracy of the Second National Water Assessment? (Circle one number in each column)

CONTENT	ACCURACY	
1	1	VERY SATISFIED
2	2	SATISFIED
3	3	NEITHER SATISFIED OR DISSATISFIED
4	4	DISSATISFIED
5	5	VERY DISSATISFIED

Q-3 Despite you satisfaction or dissatisfaction with past National Assessments, do you feel that a periodic national appraisal of the nation's water resources situation is desirable? (Circle number)

1 YES
2 NO

More specific to the scientific and management needs of Chesapeake Bay region, numerous Federal and State agencies and academic institutions have for a considerable period of time collected data concerning conditions in and around Chesapeake Bay. Recently the Environmental Protection Agency, as a part of the Chesapeake Bay Program, gathered much of this data into an accessible database.

Q-4 Have you personally used data from the "Chesapeake Bay data system" in performing your work related responsibilities? (Circle number)

1 YES ----- IF YES SKIP FROM HERE TO Q-6.
2 NO

(if no)

Q-5 Have other individuals in your organization made use of data contained in the "Chesapeake Bay data system"? (Circle number)

1 YES
2 NO ----- IF NO SKIP FROM HERE TO Q-7.

Q-6 In general, what data would you give highest priority for inclusion in the "Chesapeake Bay data system"? (Circle no more than three numbers)

1 MEASUREMENTS OF MAJOR WATER CHARACTERISTICS INCLUDING SALINITY, DISSOLVED OXYGEN, TEMPERATURE, ETC, FOR THE BAY AND TRIBUTARIES.
2 STREAM-GUAGING STATION RECORDS.
3 DEMOGRAPHIC AND ECONOMIC CHARACTERISTICS OF DRAINAGE BASIN.
4 LAND USE DATA FOR THE CHESAPEAKE DRAINAGE BASIN.
5 COMMERCIAL AND RECREATIONAL FISH HARVEST STATISTICS.
6 MEASUREMENTS OF CONCENTRATIONS OF SELECTED POLLUTANTS.
7 OTHER-PLEASE SPECIFY

____

Part II

Limited budgets require designers of public water data systems to choose what data to include in the system, and what to omit. In doing this, they try to include data having the greatest value to users. We would like to learn more about how users value different types of information and test some methods of data system design by making you the designer of your own hypothetical information system.

Q-7 Studies conducted by agencies including the Corps of Engineers and the Environmental Protection Agency have identified several potential water problems important to Chesapeake Bay. One potential problem, reduced freshwater inflows into the Bay, may result from increasing future consumption of water from its tributaries. By altering the estuarine environment, primarily by increasing salinity, declining freshwater inflows may adversely affect the Bay's aquatic life impacting commercial and recreational fishing. Potential corrective measures which have been suggested include more intensive Bay fisheries management, oyster bed restoration, and controlling inflow by 1) constructing upstream reservoirs and/or reallocating storage in existing reservoirs, 2) interbasin importation of water, 3) development of groundwater, 4) implementation of conservation programs, 5) water pricing to control demand. Assume that you are responsible for evaluating options for balancing increased water consumption with maintaining freshwater inflows. For purposes of this exercise please assume that no information appropriate for this problem exists.

Your organization has asked you to select <u>one</u> information package from the five alternatives on the facing page. This will be the only information you will be authorized to obtain. No budget limit has been set, but the cost of the information package will be deducted from the typical annual operating budget of your organization. Considering both costs and the usefulness of the information, rank the packages from most preferred to least preferred. (Write number of package in appropriate box)

☐ MOST PREFERRED ☐ 2ND MOST PREFERRED ☐ 3RD MOST PREFERRED

☐ 4TH MOST PREFERRED ☐ LEAST PREFERRED

PACKAGE 1: COST $100,000

* Estimates of current water supplies for Bay tributaries.
* Estimates of current withdrawals & consumptive use for Bay tributaries.
* Estimates of future withdrawals & consumptive use for Bay tributaries.

PACKAGE 2: COST $150,000

* Estimates of current water supplies for Bay Tributaries.
* Estimates of current withdrawals & consumptive use for Bay Tributaries.
* Estimates of future withdrawals & consumptive use for Bay Tributaries.
* Estimates of the effects of salinity on Bay marine life.

PACKAGE 3: COST $135,000

* Estimates of current water supplies for Bay Tributaries.
* Estimates of current withdrawals & consumptive use for Bay Tributaries.
* Estimates of future withdrawals & consumptive use for Bay Tributaries.
* Information describing water storage sites and potential storage in reservoirs located on Bay tributaries.

PACKAGE 4: COST $110,000

* Estimates of current water supplies for Bay Tributaries.
* Estimates of current withdrawals & consumptive use for Bay Tributaries.
* Estimates of future withdrawals & consumptive use for Bay Tributaries.
* Estimates of groundwater reserves.

PACKAGE 5: COST $125,000

* Estimates of current water supplies for Bay Tributaries.
* Estimates of current withdrawals & consumptive use for Bay Tributaries.
* Estimates of future withdrawals & consumptive use for Bay Tributaries.
* Relationship between the cost or price of water and the quantity of water consumed by tributary water users.

Q-8 Again assume that you are responsible for analyzing the declining freshwater inflow problem in the Chesapeake Bay region. For purposes of this exercise assume that you have been provided the following information.

* Estimates of current flow rates for the 5 major Bay River systems: the Susquehanna, Potomac, Rappahannock, York and James Rivers.
* Estimates of current withdrawals & consumptive use for the 5 major Bay River systems: the Susquehanna, Potomac, Rappahannock, York and James Rivers.
* Estimates of future withdrawals & consumptive use for the 5 major Bay River systems: the Susquehanna, Potomac, Rappahannock, York and James Rivers.

In addition to this information you are given a budget of $100,000 which may only be spent on information acquired from the following list. <u>After reviewing all the selections and being careful not to exceed a total expenditure of $100,000</u>, circle the numbers of the information items that you would include in your most preferred information system.

1 ESTIMATES OF CURRENT FLOW RATES FOR INDIVIDUAL STREAMS LOCATED WITHIN THE 5 MAJOR RIVER SYSTEM DRAINAGES [COST $15,000].

2 ESTIMATES OF CURRENT WITHDRAWALS & CONSUMPTIVE USE FOR INDIVIDUAL STREAMS LOCATED WITHIN THE 5 MAJOR RIVER SYSTEM DRAINAGES [COST $15,000].

3 ESTIMATES OF FUTURE WITHDRAWALS & CONSUMPTIVE USE FOR INDIVIDUAL STREAMS LOCATED WITHIN THE 5 MAJOR RIVER SYSTEM DRAINAGES [COST $20,000].

4 EFFECTS OF VARIOUS FRESHWATER INFLOW RATES ON LEVELS OF SALINITY IN THE BAY [COST $20,000].

5 RELATIONSHIP BETWEEN COST OR PRICE OF WATER AND QUANTITY OF WATER CONSUMED BY MAJOR TRIBUTARY WATER USERS [COST $20,000].

6 INFORMATION DESCRIBING THE HYDROLOGIC INTERRELATIONSHIP OF GROUNDWATER AND SURFACE WATER IN SUB-REGIONS OF THE CHESAPEAKE BAY DRAINAGE [COST $35,000].

7 ANALYSIS OF CONSUMPTIVE WATER USE RIGHTS IN THE CHESAPEAKE BAY DRAINAGE [COST $10,000].

8 ESTIMATES OF THE TOLERANCE OF IMPORTANT BAY PLANT AND ANIMAL SPECIES TO CHANGES IN LEVELS OF SALINITY [COST $30,000].

9 INFORMATION DESCRIBING STORAGE SITES AND POTENTIAL STORAGE IN RESERVOIRS LOCATED ON BAY TRIBUTARIES [COST $30,000].

10 ESTIMATES OF THE COSTS AND EFFECTIVENESS OF FISHERIES MANAGEMENT TO PROMOTE COMMERCIAL HARVEST [COST $20,000].

11 HISTORICAL RECORD OF WITHDRAWALS AND CONSUMPTIVE USE FOR INDIVIDUAL STREAMS LOCATED WITHIN THE 5 MAJOR RIVER SYSTEM DRAINAGES [COST $10,000].

12 ESTIMATES OF THE ECONOMIC VALUE OF WATER TO TRIBUTARY WATER USES [COST $25,000].

13 ESTIMATES OF THE ECONOMIC IMPACT OF DECREASED FRESHWATER INFLOWS ON RECREATIONAL AND COMMERCIAL FISHING [COST $25,000].

14 ESTIMATES OF GROUND WATER RESERVES IN THE CHESAPEAKE BAY DRAINAGE [COST $30,000].

15 ESTIMATES OF THE COSTS AND WATER SAVING POTENTIAL OF WATER CONSERVATION PROGRAMS [COST $10,000].

16 ESTIMATES OF CURRENT AND FUTURE GROUND WATER WITHDRAWALS [COST $25,000].

17 INFORMATION ON THE POTENTIAL FOR, AND COSTS OF, INTERBASIN WATER TRANSFERS [COST $20,000].

Part III

Finally, we would like to ask some questions about you and your organization to help us interpret the results.

Q-9 Which best describes your current employment? (Circle number)

1 FEDERAL GOVERNMENT AGENCY
2 STATE GOVERNMENT AGENCY
3 REGIONAL ORGANIZATION
4 LOCAL GOVERNMENT
5 PRIVATE INDUSTRY →
6 UNIVERSITY →
7 OTHER -PLEASE SPECIFY →

IF YOU ANSWERED 5, 6, or 7 SKIP TO Q-11.

____

Q-10 Which best describes the primary mission orientation of your organization? (Circle one number)

1 RESOURCE DEVELOPMENT
2 RESOURCE PLANNING
3 ENVIRONMENTAL REGULATION
4 NATURAL RESOURCE MANAGEMENT
5 SCIENTIFIC-INVESTIGATIVE
6 OTHER -PLEASE SPECIFY

____

Q-11 What is the name of the parent organization for which you work?

__________________________name

Q-12 For what division or branch of this organization do you work?

__________________________name

Q-13 What is your job title?

__________________________job title

Q-14 Where are you employed within this organization? (Circle number)

1 HOME OFFICE
2 FIELD OFFICE

Q-15 Approximately, what was your division or branch's most recent total annual operating budget for planning, agency operations, and research and development?

_______________dollars

Q-16 How long have you been employed by this organization?

_______________years

Q-17 What percent of your professional time is devoted to each of the following areas of responsibility?

(RESPONSIBILITY)	(PERCENT)
BUDGET ALLOCATION	________
RESEARCH AND DEVELOPMENT	________
FUTURE PROGRAM PLANNING	________
AGENCY OPERATIONS	________
OTHER-PLEASE SPECIFY	
____________________	________
Total	100%

Q-18 How long have you been professionally active in water resource issues?

________________years

Q-19 What is the highest level of education that you have completed? (Circle number)

1 HIGH SCHOOL
2 SOME COLLEGE
3 FOUR YEAR COLLEGE DEGREE
4 SOME POST GRADUATE WORK
5 MASTER'S DEGREE
6 PH.D
7 OTHER -PLEASE SPECIFY

____

Q-20 Which of the following best describes the primary subject area of your professional training? (Circle one number)

1 ENGINEERING
2 HYDROLOGY
3 LAW
4 BIOLOGY-LIFE SCIENCES
5 GEOLOGY-EARTH SCIENCES
6 ECONOMICS
7 OTHER SOCIAL SCIENCES
8 PUBLIC ADMINISTRATION
9 BUSINESS ADMINISTRATION/MANAGEMENT
10 OTHER -PLEASE SPECIFY

____

Is there any thing else you would like to tell us about public water data collection priorities, or about this questionaire? Please use this space for that purpose.

YOUR HELP IN COMPLETING THIS
EFFORT IS GREATLY APPRECIATED!

Department of Agricultural Economics
Virginia Tech
Blacksburg, VA 24061

Appendix C

RESPONDENT SURVEY COMMENTS

Comments Received From

Missouri River Basin Survey Respondents

All reports should include discussion about projected pressing significant water resource problems.

The state of Montana is currently undergoing its state wide water adjudication process. When complete the state will be better equipped to understand the extent of competition for water.

One improvement to the FED water data system is the "Stream flow/Basin Characteristics File", in USGS's WATSTORE. Date of latest update should be given for each individual characteristic. An indication of the probable accuracy should be given for each characteristic. Need more safeguards against erroneous data.

Feels that periodic assessments are desirable if "done properl".

Periodic assessments are desirable for planners at National Level. Little use for states due to lack of detail. Forecasts are usually outdated or inaccurate. Accurate basic data on ground and surface water resources is vital to making water resources decisions. The USGS should continue to provide adequate funding for stream gauging and groundwater data acquisition.

The USGS should inform potential users how to access information from WATSTORE or federal water data system. What good is it if you do not know how to obtain the information. Once a year they should conduct a one day class on how to get into WATSTORE and what's available, etc.

Because of budget cut backs, there is less water resource data being collected at a time when more is necessary. coordination among Fed, State and local agencies is vital to collect data that is useful for more than one purpose. At the same time Congress and the Executive Branch need to be aware that collection of water resource data is necessary to make intelligent choices in land and resource management.

Past performance of major drainage basin organizations such as the Missouri River Basin Commission have proven to be a failure from a practical standpoint. Politically, these guys have a great time planning with nothing following up on the ground. The money spent on developing basin-wide plans (e.g. water right allocations, plans, instream uses, future needs, etc.) should be allocated to individual states for onsite work. If we didn't have to spend so much time patting these politicians on the back and telling them that they are doing a great job at their monthly meetings, not to mention the costs, we could get something done on the ground. For ten years we have tried to obtain a budget for a centralized data system for groundwater. There has always been enough money for meetings etc. A higher priority should be given to allowing data users an opportunity to decide where part of the budgets are spent.

The volume of water withdrawals is our largest area of need.

I worked on the Second National Assessment. Failure to disaggregate basin data to state boundaries made the assessment useless to our state, and most others.

Any assessment of water resources must use figures that are representative of actual conditions to be of any value and to assign of confidence factor. Most all assessments that I have either seen or worked with use "arithmetic averages". There is no stream on this continent that can demonstrate a symmetrical distribution of flows and the same can be said for uses. Therefore, the arithmetic average is the wrong central tendency value to use in water assessments. Duration curves are by far more meaningful or goodness of fit tests should be employed to determine the correct central tendencies to make an assessment truly representative. The Federal Government agencies and all the states have the capability to generate good data on stream flow, uses, etc. Through the use of the software available to them.

I would really like to see the Federal Government do a better job of coordinating and linking their water information data bases. EPA has really done a poor job of this . . . We as data users really appreciate the coordination which has been done between WATSTORE and STORET. It makes our job a lot easier.

The collection of data must be targeted to the needs of the user. The bottom line user is not academia. The real users are people like myself that have to make policy decisions that affect the use of water.

A copious amount of data are available on a state and county basis but not on a basin-by-basin basis. Getting the information for across the state line or county line for a particular watershed is sometimes difficult. I would like an executive summary of the results of this survey.

Need to add a category to Q-8: Estimates of Surface Water Quality.

Ground water withdrawals were not included in the choices. Why are you rehashing the National Water Assessments that have been replaced by the USGS National Water Summaries each year? Why not ask about the suitability of the Summaries? I predict you will have a real mess if your sample is small as you indicated in the transmittal letter.

The questionnaire design was lousy. Too many assumptions, too much busy work, too complicated. Submitted Constructively.

The questionnaire is not geared to address a main problem and this is lack of federal funding to maintain and secure water records (surface and ground) throughout our Regional network. The DOI agencies, have been for several years, trying to inform the USGS of our needs and to impress upon them the need for additional funding. As of yet, our concerns have been ignored. In 1983 the DOI agencies prepared the document "Hydrologic needs of the USDOI for the Upper Missouri River Basin". The appropriate people need to be convinced, especially in light of the continuing water- related problems that regional networks of data gathering is needed. In order to perform hydrologic studies and investigations, real-time water records are necessary.

Let us determine economicsYou provide the water data. USGS is not the agency to be studying economics.

Additional Category to Q-8: Potential reuse of withdrawals to lower need or optimize use-also potential improved efficiency in returning withdrawals after use to the river.

Preparation of digital maps and data will greatly enhance their use in the Geographic Information systems that will be use in future water resources planning. Attention should be given to standardization.

Need better handle on water use by all users and on interaction between groundwater use and surface water use.

Activities need to be coordinated. Water Resource planning and development ($) needed. Basin compact needed.

"Notes that COE was Developmental but now is Regulatory".

USGS money is best spent on data collection. Lots of USGS "research" is trivial, low-priority, or better done in Universities or private sector.

Regarding your questionnaire, our agency is primarily oriented toward protecting the quality of surface and ground waters, and the beneficial uses assigned to each water body. Pursuant to this we are interested in water quantity-quality relationships, interrelationships between surface and ground waters, and in instream flow rates required to maintain and support aquatic life populations.

The state is able to collect adequate data (for our purposes) on traditional water quality parameters. Information that we do not have the resources to obtain include areas that overlap into other disciplines such as quality-quantity relationships, instream economic values, hydrologic interrelationships of surface and groundwater, etc. This information is necessary to plan a comprehensive water quality program which is practical and effective.

USGS needs to maintain their high quality cadre of people that can stick to basics - collect good data and make it available. Too many irons in the fire will devalue all of it.

Agencies such as USGS should focus on data collection -- streamguaging, groundwater, etc. Analysis of data should be the responsibility of the users. I don't believe USGS should be involved in economic or environmental analyses.

How did I get on your mailing list? I don't think Minnesota is in the Missouri River Basin.

I really don't agree that we should assume no work has been done in various areas of water management, as you suggest in Q-7 and Q-8. When a particular piece of information is available, it seems the problem is solved. I do know for example that Ft. Peck Tribes has quantified water rights on the Missouri, even though I answered that money needed to be placed in this area. Remember you told me to assume no information was available.

Suggests new category to Q-8: Effects of various instream flow rates on stability and maintenance of channel systems (Cost $30,000). There is a definite need to collect surface water data from smaller, higher elevation watersheds, particularly where precipitation is snow dominated, to include sediment water yield relationships.

I would appreciate it if you wouldn't bother my department with these surveys in the future. The federal government will do what it has available funding to do regardless of all the surveys you people run for the next 100 years.

Our hydroscience Section uses exceedence frequency analysis from USGS for water availability studies and has one major problem with these analyses. As set up, they can be run with only 9,19,29, etc. years of data so that exceedence frequencies come out as multiples of 10. They would prefer to use 5 more years of data, get an uneven exceedence frequency, and interpolate to get the desired value.

National appraisals of the nation's water resources are not desirable on a National scale. A study of the whole nation in one effort dilutes all areas of study and makes the results too general to be very useful. Notes that in Q-7 "there is no information on past demands included in the packages; a major limitation in the information data base here". Notes in Q-8, "historical information provided by political boundary for water studies is of very little value". Final comment, "Without consistently reliable, accurate and adequate water resources data, objective water resources management decisions cannot be made. It has always been difficult to justify to those politically motivated forces directing public opinion that significant data collection efforts are worthwhile. Therefore, the mainstay of water resources data collection responsibility must stay under the direction of federal agencies. The characteristics of the data collection network must be developed from a long range and scientific perspective without major influences from local interest groups with narrow and short term perspectives.

Comments Received From

Chesapeake Bay Drainage Survey Respondents

We are in need of periodic national water resources assessments focusing on both quantity and quality. In this regard the Congress should establish an entity to fill the critical void left by the disestablishment of the Water Resources Council.

The most recent enlargement of the C canal to a 35 foot channel depth became effective about 1970. The net exchange of water between Delaware Bay and Chesapeake Bay through the C canal has potentially far more significance on freshwater inflows to the Bay than all other consumptive uses combined. Any realistic evaluation of changes in freshwater inflow to the Bay must include a verifiable estimate of the C canal situation. Changes in water consumption which could actually be affected by higher water prices would be insignificant.

Projections of demand by 4-digit hydrologic subregions are essential.

Suggests that recreation (as a nonconsumptive use) uses are included in data and that attempts be made to define the economic worth of nonconsumptive uses (i.e. recreation).

Whatever water data collection system is set up it needs to be standardized among all water collection agencies in format and in common data base for computer adaptability.

Quantitative water use data from all types of users must be updated preferably every five years and at a minimum every decade.

Costs of ranking packages are unrealistic and will undoubtedly bias the results of the question.

Periodic assessments of the nation's water resources are probably too broad to be useful.

The example you chose (low flow) is a poor one. It perhaps more than any other is a misdirected effort. There was undoubtedly less water inflowing to Chesapeake Bay at settlement than now. It is doubtful that consumption in the future could match that of the evaporative losses of the forest (which covered this region in presettlement times). This has been an extremely frustrating questionnaire.

While you may not have asked for my name, you could certainly obtain it with the information contained in the questionnaire. If results of this survey are published, please furnish me with a copy.

This seems to be primarily a SWCB responsibility for the Virginia portion of the area-current EPA grant to that agency would include their addressing many of these questions.

Data needs to focus on substantiating causal relationships postulated in theory. In other words, let's have a purpose in mind rather than collect data for data's sake.

Periodic assessments of our nation's water resources are not only desirable, but as essential as population censuses.

Policy analysts need pre-digested water quality data. Possibly a water quality index.

I think you have narrowed the choices far too much. Water resources planning is a broad area and involves the entire hydrologic cycle. In addition to precipitation (input), surface runoff, ground water and evapotranspiration, one needs to look at how mankind treats and affects water as it goes through this cycle. Anything less is an incomplete picture.

How is this confidential if you've identified specific positions within departments?

Feels that determination on whether periodic national assessments are desirable depends upon the costs.

In response to Ranking Question: My agency would not select any of these "packages". The cost seems high for any of these "packages". Does the cost include cost of doing the surveys necessary? If Corps & EPA do the studies, why is the cost so high for access to data?

Flow and Quality data need to be related to each other (i.e. don't give me quality data if the flow for that particular sample is not available). Also time of year is important when looking at consumptive use compared to naturally occurring resource. Yearly averages did not provide as meaningful data as do monthly(weekly) data for the critically high or low flows.

Due to concern of atmospheric deposition and effects on aquatic environment, water quality parameters per EPA protocol should be collected.

Would be particularly interested in data relating to groundwater contamination by herbicides and pesticides as a function of soil type and geology.

It is obvious that the major water resource agency involved in collecting and disseminating this information must do a better job of coordinating their efforts. We should complement one another to the extent possible and insure that the information we publish has a defined user community. Where possible we should attempt to consolidate our data systems for mutual use.

I think one of the best expenditures of time and money for a government agency in this area is to help the public understand the economics and ecological impacts of alternative actions for decision making purposes.

A well designed questionnaire.

You're not asking the right questions This is a questionnaire for hydrologists. All five of the bundles are irrelevant as are the information items in question 8.

I am most interested in this study. Please keep me informed.

Your questionnaire categories are a little too simplistic (Q-7, Q-8) as they suggest decision being made in a vacuum of other information. This is never the case. Also implicit in some assumptions (Q-8) would be correlative information which would condition the choices, but which is neither states as present, nor excluded from the assumed existent data base.

Because of widely varying methods of evaluation the National Assessment process has proven to yield misleading results which are oft-quoted as gospel (see ASIWPCA reports).

I believe it is quite important to develop a "finger print" of ALL the rivers and tributaries of the U.S. Measurable changes in one or more parameters could identify problems, either real or developing, with a likely source already within the data base.

Please Share Your Results I like the example on FW diversions in Part II. Too many people think it's not a water quality/ environmental problem, especially the fisheries.

I believe that the major need is development of a coordinated plan/program-of-study designed to define the problem, determine what we already know and don't know, and define the studies which are necessary and assign responsibilities, and establish schedules for completion. The Corps is conducting a follow-up to their previous work but hasn't coordinated with others.

For R & D, more details are required than the general statements and data in the USWRC assessment documents.

Our focus here at EPA is on quality of water. Quantity is really not considered. From EPAs perspective, in a period of dwindling financial resources, the highest priority must be given to collecting and analyzing the data which will allow and help states and local jurisdictions to establish priorities among the (too) many good projects which need attention and then enable them to push on with IMPLEMENTATION.

Estimates of water parameters are usually useless, but are very popular by those who can't measure anything. I would not trust the estimates. Measurements of quantities are needed. Flow rates are not meaningful. I would not waste money on estimates but will play the game (Q-8).

I'm sure that this questionnaire has taken into consideration the fact that people with different backgrounds will most probably have different priorities (e.g. engineer vs. biologist) when it comes to water resources planning. Personally I believe in directed development and water collecting and purifying systems.

I think this is a well thought-out and designed survey. I would like to receive a copy of the results. I think a data base designed around components of question Q-8 could make it a very useful management tool. I selected package three for question Q-7 because I think growth is inevitable in the Chesapeake Bay region and we ought to be taking management steps now to prepare for it. Once the water storage sites are identified assuming we do so now, that should leave time for the necessary environmental studies in the potential storage site locations.

Appendix D

SURVEY GROUP CHARACTERISTICS

Characteristics of Missouri River Basin Survey Respondents

Simple statistics for behavioral model variables considered in the Missouri River Basin survey analyses are presented in Table D.1 The means of binary variables refer to the proportion of respondents taking on the particular qualitative attributes. For example, the mean for FEDFLD indicates that approximately 14 percent of the sample respondents were employed by a regional office of a federal agency.

In addition to the variables listed in Table D.1, other characteristics of the sample group were obtained. In terms of education, all respondents had at least some level of college education. Eighteen percent of the sample had completed a four year college degree while an additional 17 percent had some post-graduate training. Sixty one percent of the sample had a Masters degree or above. The average length of time the respondent had been employed by his organization was 12 years with a range of 1-35 years. With regard to satisfaction with the content past National Water Assessments, 48 percent of those who had used the Second National Water Assessment indicated that they were satisfied or very satisfied, 27 percent were neither satisfied or

TABLE D.1

Simple Statistics for Model Variables - Missouri River Basin

VARIABLE	MEAN	STANDARD DEVIATION
USE	.31193	.46542
EXPA	5.6192	2.2193
FEDFLD	.13761	.34609
STATEREG	.69725	.46157
SCINV	.15596	.36450
REGMGT	.48624	.50212
BUDGET	639.39	1727.6
BUDP	7.2752	6.7753
PPP	26.56	22.041
AOP	44.431	27.699
ACTIVE	14.512	8.4440
SOCSI	.08256	.27650
PHYBIO	.18349	.38885
PABM	.20183	.40322

dissatisfied, while 25 percent indicated that they were dissatisfied or very dissatisfied. With regard to the accuracy of the information in past National Water Assessments, 36 percent stated that they were satisfied or very satisfied, 46 were neither satisfied or dissatisfied, and 18 percent indicated that they were dissatisfied or very dissatisfied. When asked their opinion on the desirability of periodic national assessments of the nation's water resources, only 4 percent indicated that such exercises were not desirable.

Characteristics of Chesapeake Bay Drainage Survey Respondents

Simple statistics for behavioral model variables considered in the Chesapeake Bay Drainage survey analyses are presented in Table D.2 As before, the means of binary variables refer to the As those statistics indicate, 20 percent of the respondents indicated that they had used the Second National Water Assessment. With respect to marginal expenditures on "assessment information", a mean expenditure of $45,000 was recorded with 95% of the respondents spending between $85,000 and $105,000.

Approximately 20 percent of the sample respondents were employed by a Federal nonheadquarters agency, 40 percent by state or regional organizations, and consequently the remaining 40 percent were employed by Federal headquarters agencies. Almost 12 percent of the respondents indicated that the mission of their agency was primarily resource planning, while 19 percent, 41 percent and 18 percent indicated that their agency mission was environmental regulation, resource management and scientific-investigative respectively. The remaining 10 percent of the sample group indicated that resource development was the primary mission of their agency. The mean division or branch annual operat-

TABLE D.2

Simple Statistics for Model Variables - Chesapeake Bay Drainage

VARIABLE	MEAN	STANDARD DEVIATION
USE	.20395	.40426
EXPA	4.500	2.870
FEDFLD	.20395	.40426
STATEREG	.40132	.49179
RESPLN	.11842	.32417
ENVREG	.19079	.39422
RESMGT	.40789	.49307
SCINV	.18421	.38895
BUDGET	830.92	1786.3
BUDP	7.8388	7.0426
PPP	21.039	19.858
AOP	54.092	29.727
ACTIVE	15.076	8.8673
SOCSI	.06579	.24873
PHYBIO	.52632	.50096
PABM	.07895	.27055

ing budget was $8.3 million. On average, respondents allocated their professional time by spending 8 percent on budget allocation/preparation, 21 percent on program planning, and 54 percent on agency operations. Average years of involvement in water resource issues was a little more than 15 years. Finally, approximately 7 percent of the respondents stated that their professional training was in the social sciences, while 53 percent and 8 percent respectively indicated training in the physical/biological sciences and public administration/business management. The remaining 32 percent were trained in engineering and hydrology.

In addition to the variables covered in Table D.2, other characteristics of the sample group were obtained. As in the Missouri River basin survey, all respondents had at least some level of college education. Fourteen percent of the sample respondents had completed a four year college degree while an additional 22 percent had some amount post-graduate training. Sixty three percent of the sample had a Masters degree or above (47 percent Masters Degree, 16 percent Ph.D.). The average length of time the respondent had been employed by his organization was 14 years with a range of 1 to 37 years. With regard to satisfaction with the content past National Water Assessments, 80 percent of those who had used the Second National Water Assessment indicated that they were satisfied or very satisfied, 10 percent were neither satisfied or dissatisfied, while 10 percent indicated that they were dissatisfied. With regard to the accuracy of the information in the Second National Water Assessment, 58 percent stated that they were satisfied or very satisfied, 29 were neither satisfied or dissatisfied, while the remaining 13 percent indicated that they were dissatisfied. As in the Missouri River basin survey, when asked their opinion on the desirability of periodic national assessments of the nation's water resources, only 4 percent indicated that such exercises were not desirable.

Appendix E

SURVEY DATA

MISSOURI RIVER BASIN SURVEY DATA

OBS	USE	EXPA	FEDHOM	FEDFLD	STATEREG	DVLPLN	SCINV	REGMGT	BUDGET	IBUDGET	ENGHY	SOCSI
1	1	8.00	0	0	1	0	0	1	800.00	.00125	1	0
2	0	9.00	0	0	1	0	0	1	600.00	.00167	1	0
3	0	6.00	0	0	1	0	1	0	100.00	.01000	0	1
4	0	1.00	0	0	1	0	1	0	25.00	.04000	1	0
5	0	7.00	0	0	1	0	0	1	80.00	.01250	1	0
6	0	7.00	0	0	1	0	0	1	120.00	.00833	0	0
7	0	7.50	0	0	1	0	0	1	120.00	.00833	1	0
8	1	9.50	0	0	1	1	0	0	300.00	.00333	0	1
9	1	6.00	0	0	1	1	0	0	300.00	.00333	1	0
10	0	3.50	0	0	1	0	0	1	250.00	.00400	1	0
11	0	5.00	0	0	1	0	0	1	300.00	.00333	1	0
12	0	8.00	0	0	1	0	1	0	50.00	.02000	1	0
13	0	5.00	0	0	1	0	1	0	50.00	.02000	1	0
14	0	6.50	0	0	1	0	0	1	130.00	.00769	0	0
15	0	6.50	0	0	1	0	0	1	30.00	.03333	0	0
16	1	5.00	0	0	1	0	0	1	10.00	.10000	0	0
17	1	5.00	0	0	1	0	0	1	10.00	.10000	1	0
18	0	3.00	0	0	1	0	0	1	40.00	.02500	0	0
19	0	3.50	0	0	1	0	0	1	20.00	.05000	0	0
20	0	5.50	0	0	1	0	0	1	2500.00	.00040	0	0
21	1	6.00	0	0	1	0	1	0	30.00	.03333	1	0
22	0	.00	0	0	1	0	0	1	400.00	.00250	0	0
23	0	10.00	0	0	1	0	0	1	15.00	.06667	1	0
24	0	4.00	0	0	1	0	0	1	610.00	.00164	0	0
25	0	7.00	0	0	1	1	0	0	70.00	.01429	0	0
26	0	1.50	0	0	1	0	0	1	850.00	.00118	0	0
27	0	5.00	0	0	1	0	0	1	170.00	.00588	1	0
28	1	8.00	0	0	1	0	0	1	140.00	.00714	1	0
29	0	4.50	0	0	1	0	1	0	250.00	.00400	0	0
30	0	7.00	0	0	1	1	0	0	120.00	.00833	1	0
31	1	6.50	0	0	1	1	0	0	80.00	.01250	0	0
32	0	3.00	0	0	1	0	0	1	150.00	.00667	0	0
33	0	3.00	0	0	1	0	0	1	150.00	.00667	0	0
34	1	2.00	0	0	1	1	0	0	63.50	.01575	0	0
35	0	6.50	0	0	1	0	0	1	120.00	.00833	1	0
36	0	6.50	0	0	1	0	1	0	25.00	.04000	0	0
37	0	4.50	0	0	1	0	0	1	120.00	.00833	0	0
38	0	6.50	0	0	1	0	0	1	120.00	.00833	1	0
39	0	8.00	0	0	1	0	0	1	22.90	.04367	1	0
40	1	4.00	0	0	1	0	0	1	84.60	.01182	1	0
41	0	5.50	0	0	1	0	1	0	120.00	.00833	0	0
42	1	6.50	0	0	1	1	0	0	100.00	.01000	1	0

OBS	USE	EXPA	FEDHOM	FEDFLD	STATEREG	DVLPLN	SCINV	REGMGT	BUDGET	IBUDGET	ENGHY	SOCSI
43	1	8.00	0	0	1	1	0	0	100.00	.01000	0	0
44	0	4.00	0	0	1	1	0	0	100.00	.01000	1	0
45	0	7.50	0	0	1	0	0	1	325.00	.00308	1	0
46	0	8.00	0	0	1	1	0	0	25.00	.04000	0	0
47	0	5.00	0	0	1	1	0	0	25.00	.04000	1	0
48	0	5.00	1	0	0	0	0	1	150.00	.00667	1	0
49	0	5.00	1	0	0	0	0	1	1800.00	.00056	0	1
50	0	6.50	1	0	0	0	0	1	1800.00	.00056	1	0
51	1	7.00	1	0	0	0	0	1	300.00	.00333	1	0
52	1	5.00	1	0	0	0	0	1	270.00	.00370	1	0
53	1	8.00	0	1	0	1	0	0	200.00	.00500	1	0
54	1	5.00	1	0	0	1	0	0	15.00	.06667	1	0
55	1	10.00	1	0	0	1	0	0	10000.00	.00010	1	0
56	0	2.50	1	0	0	0	1	0	100.00	.01000	1	0
57	0	7.50	1	0	0	0	0	1	170.00	.00588	1	0
58	0	7.00	1	0	0	1	0	0	300.00	.00333	1	0
59	0	3.00	0	1	0	0	0	1	200.00	.00500	1	0
60	0	7.50	0	1	0	0	0	1	1500.00	.00067	1	0
61	0	9.00	0	1	0	0	0	1	1500.00	.00067	1	0
62	1	5.00	0	1	0	0	0	1	2900.00	.00035	0	0
63	1	2.00	0	1	0	0	0	1	2900.00	.00035	0	0
64	1	6.00	1	0	0	1	0	0	35.00	.02857	1	0
65	1	9.50	1	0	0	1	0	0	200.00	.00500	1	0
66	0	2.00	0	1	0	0	0	1	100.00	.01000	0	0
67	1	7.50	1	0	0	0	1	0	330.00	.00303	0	0
68	1	3.00	0	0	1	0	0	1	520.00	.00192	0	0
69	0	7.00	0	0	1	1	0	0	20.00	.05000	0	1
70	1	5.50	0	1	0	0	0	1	100.00	.01000	1	0
71	0	.00	0	0	1	1	0	0	15.00	.06667	0	0
72	0	7.00	0	0	1	0	0	0	10.00	.10000	1	0
73	0	5.00	0	1	0	0	0	1	60.00	.01667	0	0
74	0	3.00	0	0	1	0	0	1	600.00	.00167	0	1
75	1	3.50	0	0	1	1	0	0	100.00	.01000	0	1
76	0	3.50	0	0	1	0	0	1	20.00	.05000	0	0
77	0	5.50	0	0	1	1	0	0	10.00	.10000	1	0
78	1	4.50	1	0	0	1	0	0	75.00	.01333	1	0
79	0	3.00	0	0	1	0	0	1	200.00	.00500	1	0
80	0	5.00	0	0	1	0	0	1	4550.00	.00022	0	0
81	1	6.50	0	0	1	0	0	0	30.00	.03333	1	0
82	1	4.00	0	0	1	0	0	1	215.00	.00465	0	0
83	0	2.00	0	0	1	1	0	0	20.00	.05000	0	1
84	0	5.00	0	1	0	1	0	0	10000.00	.00010	1	0
85	0	3.50	0	1	0	1	0	0	1000.00	.00100	1	0
86	0	8.00	1	0	0	1	0	0	1000.00	.00100	1	0
87	0	4.50	0	0	1	0	1	0	150.00	.00667	0	0

OBS	USE	EXPA	FEDHOM	FEDFLD	STATEREG	DVLPLN	SCINV	REGMGT	BUDGET	IBUDGET	ENGHY	SOCSI
88	0	8.00	0	0	1	0	0	0	40.00	.02500	1	0
89	1	3.00	0	1	0	1	0	0	230.00	.00435	0	0
90	0	5.00	0	0	1	1	0	0	800.00	.00125	1	0
91	1	7.50	0	0	1	0	1	0	300.00	.00333	0	0
92	0	3.50	0	0	1	0	1	0	100.00	.01000	0	0
93	0	3.00	0	0	1	0	0	1	1100.00	.00091	0	0
94	1	5.00	0	0	1	1	0	0	50.00	.02000	0	1
95	0	6.00	0	0	1	1	0	0	10.00	.10000	0	1
96	0	5.50	0	0	1	0	0	1	27.50	.03636	0	0
97	0	8.00	0	0	1	1	0	0	22.50	.04444	0	0
98	0	6.50	0	1	0	0	1	0	1800.00	.00056	1	0
99	0	4.00	0	0	1	1	0	0	100.00	.01000	1	0
100	0	8.00	0	0	1	0	1	0	2.00	.50000	0	0
101	0	7.00	0	0	1	0	0	1	700.00	.00143	0	0
102	1	5.50	1	0	0	1	0	0	72.50	.01379	1	0
103	0	8.00	1	0	0	1	0	0	99.70	.01003	1	0
104	1	10.00	0	1	0	1	0	0	10000.00	.00010	1	0
105	1	3.50	0	0	1	1	0	0	81.40	.01229	0	0
106	0	6.50	0	0	1	0	1	0	150.00	.00667	0	0
107	0	7.00	1	0	0	0	0	1	270.00	.00370	1	0
108	0	7.50	0	0	1	0	0	1	35.00	.02857	1	0
109	0	10.00	0	1	0	0	1	0	30.00	.03333	1	0

MISSOURI RIVER BASIN SURVEY DATA (CONT)

OBS	PHYBIO	PABM	BUDP	PPP	AOP	ACTIVE	IACTIVE	RANK1	RANK2	RANK3	RANK4	RANK5
1	0	0	5	10	50	25.00	.0400	1	3	4	5	2
2	0	0	5	20	55	15.00	.0667	4	1	3	2	5
3	0	0	10	40	30	5.00	.2000	4	3	1	2	5
4	0	0	1	50	10	8.00	.1250	2	5	4	3	1
5	0	0	10	20	60	17.00	.0588	4	3	2	5	1
6	1	0	1	9	70	15.00	.0667	3	2	5	4	1
7	0	0	3	20	60	5.00	.2000	3	1	4	5	2
8	0	0	0	5	10	1.00	1.0000	4	3	5	1	2
9	0	0	0	60	30	6.00	.1667	3	2	4	1	5
10	0	0	10	20	40	15.00	.0667	3	2	4	1	5
11	0	0	2	5	88	8.00	.1250	2	3	4	5	1
12	0	0	5	10	5	7.00	.1429	3	4	5	2	1
13	0	0	5	10	5	20.00	.0500	5	4	1	3	2
14	1	0	15	15	55	26.00	.0385	3	4	5	1	2
15	1	0	5	20	70	20.00	.0500	4	3	1	2	5
16	0	1	0	0	80	25.00	.0400	4	3	1	2	5
17	0	0	0	40	40	7.00	.1429	4	1	3	2	5
18	1	0	5	10	80	17.00	.0588	2	4	3	1	5
19	1	0	5	65	20	15.00	.0667	2	4	5	3	1
20	0	1	10	30	50	1.00	1.0000	4	1	3	5	2
21	0	0	5	15	10	11.00	.0909	2	1	4	3	5
22	0	1	25	10	50	33.00	.0303	2	5	3	4	1
23	0	0	1	25	49	15.00	.0667	4	3	2	5	1
24	0	1	5	40	50	35.00	.0286	3	4	5	2	1
25	0	1	10	25	40	5.50	.1818	4	1	3	5	2
26	0	1	15	20	60	10.00	.1000	5	3	4	2	1
27	0	0	5	5	80	6.00	.1667	3	1	5	2	4
28	0	0	0	0	40	15.00	.0667	1	4	3	2	5
29	1	0	10	10	70	28.00	.0357	2	4	1	3	5
30	0	0	5	30	15	12.00	.0833	1	2	5	3	4
31	0	1	5	20	75	25.00	.0400	3	2	4	1	5
32	1	0	0	100	0	4.75	.2105	2	4	3	1	5
33	1	0	0	45	10	7.00	.1429	3	2	1	4	5
34	0	1	5	10	80	20.00	.0500	2	5	3	4	1
35	0	0	10	20	50	12.00	.0833	3	1	4	5	2
36	1	0	5	20	25	25.00	.0400	3	1	4	5	2
37	0	1	30	30	40	6.00	.1667	2	4	5	1	3
38	0	0	5	30	60	13.00	.0769	1	3	4	2	5
39	0	0	5	0	25	10.00	.1000	1	3	2	5	4
40	0	0	10	30	40	11.00	.0909	2	3	5	4	1
41	1	0	15	25	25	25.00	.0400	4	3	5	2	1
42	0	0	5	15	10	10.00	.1000	3	1	4	2	5

OBS	PHYBIO	PABM	BUDP	PPP	AOP	ACTIVE	IACTIVE	RANK1	RANK2	RANK3	RANK4	RANK5
43	0	1	0	100	0	8.00	.1250	4	2	1	5	3
44	0	0	5	40	50	15.00	.0667	3	1	4	5	2
45	0	0	0	25	20	19.00	.0526	4	3	1	5	2
46	0	1	5	10	80	6.00	.1667	1	2	5	4	3
47	0	0	0	0	0	30.00	.0333	1	4	5	3	2
48	0	0	10	70	10	15.00	.0667	2	5	3	4	1
49	0	0	10	20	20	5.00	.2000	3	4	1	5	2
50	0	0	1	60	38	11.00	.0909	4	2	5	3	1
51	0	0	15	35	35	11.00	.0909	5	2	4	1	3
52	0	0	5	50	45	22.00	.0455	5	2	4	1	3
53	0	0	5	10	70	25.00	.0400	4	1	5	3	2
54	0	0	10	40	30	25.00	.0400	2	1	3	4	5
55	0	0	10	40	5	23.00	.0435	3	4	1	2	5
56	0	0	10	15	75	26.00	.0385	4	5	2	1	3
57	0	0	5	0	70	25.00	.0400	1	4	3	5	2
58	0	0	5	50	40	20.00	.0500	4	3	5	1	2
59	0	0	0	15	0	10.00	.1000	1	2	4	3	5
60	0	0	30	20	30	8.00	.1250	3	1	4	2	5
61	0	0	1	1	98	6.50	.1538	4	2	3	5	1
62	0	1	20	20	60	17.00	.0588	5	4	2	3	1
63	0	1	20	25	50	4.00	.2500	2	5	4	3	1
64	0	0	0	100	0	12.00	.0833	1	3	4	2	5
65	0	0	10	30	55	11.00	.0909	2	4	3	1	5
66	1	0	25	25	25	4.00	.2500	4	3	1	5	2
67	1	0	5	15	80	12.00	.0833	4	1	5	3	2
68	0	1	5	10	80	18.00	.0556	4	2	5	3	1
69	0	0	0	80	0	7.00	.1429	4	1	3	2	5
70	0	0	0	70	30	21.00	.0476	5	4	2	1	3
71	0	1	25	50	0	8.00	.1250	5	4	3	2	1
72	0	0	0	0	100	2.00	.5000	1	4	5	3	2
73	0	1	5	10	85	25.00	.0400	3	4	2	5	1
74	0	0	0	20	0	8.00	.1250	4	1	3	5	2
75	0	0	15	50	0	42.00	.0238	5	2	4	3	1
76	1	0	10	20	50	14.00	.0714	2	5	4	3	1
77	0	0	0	15	75	24.00	.0417	5	4	2	3	1
78	0	0	10	10	80	25.00	.0400	4	5	2	3	1
79	0	0	10	25	50	13.00	.0769	2	5	4	1	3
80	1	0	15	10	75	35.00	.0286	4	3	2	5	1
81	0	0	5	15	80	17.00	.0588	4	1	5	2	3
82	0	1	5	5	5	17.00	.0588	3	4	5	1	2
83	0	0	20	30	40	6.00	.1667	2	4	5	3	1
84	0	0	0	25	75	15.00	.0667	2	5	4	1	3
85	0	0	15	15	0	7.00	.1429	2	4	3	5	1
86	0	0	20	50	20	29.00	.0345	2	5	3	4	1
87	1	0	20	25	45	17.00	.0588	5	4	3	2	1

OBS	PHYBIO	PABM	BUDP	PPP	AOP	ACTIVE	IACTIVE	RANK1	RANK2	RANK3	RANK4	RANK5
88	0	0	0	40	60	2.00	.5000	4	3	2	1	5
89	1	0	10	25	50	25.00	.0400	5	2	4	3	1
90	0	0	10	50	40	5.50	.1818	4	2	5	3	1
91	0	1	10	30	50	20.00	.0500	4	5	2	3	1
92	0	1	10	10	80	9.00	.1111	1	4	2	5	3
93	1	0	5	20	50	5.00	.2000	3	1	2	4	5
94	0	0	10	10	55	8.00	.1250	1	2	4	3	5
95	0	0	5	85	5	10.00	.1000	4	5	2	1	3
96	1	0	5	50	35	9.00	.1111	4	3	5	2	1
97	0	1	5	25	50	3.50	.2857	2	4	3	5	1
98	0	0	5	25	55	19.00	.0526	4	3	2	5	1
99	0	0	5	5	85	14.00	.0714	3	4	2	5	1
100	1	0	0	0	0	12.00	.0833	4	1	2	5	3
101	1	0	5	10	65	10.00	.1000	3	2	4	1	5
102	0	0	5	10	85	12.00	.0833	4	3	2	5	1
103	0	0	5	40	50	17.00	.0588	3	2	5	1	4
104	0	0	10	20	50	23.00	.0435	4	3	5	2	1
105	0	1	10	50	30	10.00	.1000	4	3	5	2	1
106	0	1	0	10	30	5.00	.2000	3	2	4	1	5
107	0	0	10	25	65	11.00	.0909	4	5	2	3	1
108	0	0	3	10	80	19.00	.0526	4	3	1	5	2
109	0	0	5	10	85	15.00	.0667	4	3	1	2	5

NOTE: RANK1 - RANK5 REPRESENT INDIVIDUAL RANKINGS OF INFORMATION PACKAGES. (EX. RANK1 = 4 INDICATES THAT INFORMATION PACKAGE FOUR WAS MOST PREFERRED.)

CHESAPEAKE BAY DRAINAGE SURVEY DATA

OBS	USE	EXPA	FEDHOM	FEDFLD	STATEREG	RESDVL	RESPLN	ENVREG	RESMGT	SCINV	BUDGET	IBUDGET	ENGHY
1	0	7.00	0	0	1	0	0	0	1	0	50.00	.02000	1
2	0	4.00	0	0	1	0	0	1	0	0	50.00	.02000	1
3	0	3.50	0	0	1	1	0	0	0	0	5.00	.20000	1
4	0	5.50	0	0	1	0	0	0	1	0	30.00	.03333	1
5	0	6.00	0	0	1	0	1	0	0	0	20.00	.05000	1
6	0	4.50	0	0	1	0	0	1	0	0	1400.00	.00071	1
7	0	3.50	0	0	1	0	0	1	0	0	1400.00	.00071	1
8	0	.00	0	0	1	0	0	0	1	0	2700.00	.00037	1
9	0	6.50	0	0	1	0	0	0	1	0	20.00	.05000	0
10	0	9.00	0	0	1	0	0	0	0	1	250.00	.00400	0
11	0	6.50	0	0	1	1	0	0	0	0	14800.00	.00007	1
12	0	.00	0	0	1	0	0	0	1	0	270.00	.00370	0
13	0	3.00	0	0	1	0	0	0	1	0	250.00	.00400	0
14	0	5.00	0	0	1	1	0	0	0	0	4000.00	.00025	1
15	0	4.00	0	0	1	1	0	0	0	0	15.00	.06667	0
16	0	8.50	0	0	1	0	1	0	0	0	60.00	.01667	1
17	0	4.00	0	0	1	0	0	1	0	0	60.00	.01667	1
18	0	.00	0	0	1	0	0	1	0	0	80.00	.01250	0
19	0	8.50	0	0	1	0	0	1	0	0	10.00	.10000	0
20	0	3.00	0	0	1	0	0	0	1	0	50.00	.02000	0
21	0	3.50	0	0	1	0	0	1	0	0	100.00	.01000	0
22	0	8.00	0	0	1	0	0	1	0	0	350.00	.00286	1
23	0	3.00	0	0	1	0	0	1	0	0	124.70	.00802	0
24	0	2.00	0	0	1	0	0	0	0	1	124.70	.00802	0
25	0	3.00	0	0	1	0	0	0	0	1	70.00	.01429	1
26	1	4.00	0	0	1	0	0	0	0	1	70.00	.01429	1
27	1	3.50	0	0	1	0	1	0	0	0	150.00	.00667	1
28	0	1.00	0	0	1	0	0	0	1	0	45.00	.02222	0
29	1	.00	0	1	0	0	0	0	1	0	350.00	.00286	1
30	1	5.00	0	1	0	0	0	0	1	0	360.00	.00278	0
31	1	8.00	1	0	0	0	1	0	0	0	440.00	.00227	0
32	0	3.50	1	0	0	0	0	0	1	0	440.00	.00227	0
33	1	3.00	1	0	0	0	1	0	0	0	220.00	.00455	1
34	0	5.00	1	0	0	0	1	0	0	0	200.00	.00500	0
35	0	8.50	0	1	0	0	0	0	0	1	350.00	.00286	1
36	0	4.50	0	1	0	0	0	0	0	1	350.00	.00286	1
37	0	3.50	1	0	0	0	0	0	1	0	100.00	.01000	0
38	0	6.00	1	0	0	0	1	0	0	0	50.00	.02000	0
39	0	6.00	0	1	0	0	0	0	0	1	50.00	.02000	0
40	0	.00	0	1	0	0	0	0	1	0	100.00	.01000	0
41	1	5.50	1	0	0	0	0	0	1	0	200.00	.00500	0
42	0	6.00	1	0	0	0	0	0	0	1	350.00	.00286	0

OBS	USE	EXPA	FEDHOM	FEDFLD	STATEREG	RESDVL	RESPLN	ENVREG	RESMGT	SCINV	BUDGET	IBUDGET	ENGHY
43	1	5.50	1	0	0	0	0	0	0	1	300.00	.00333	1
44	0	.00	1	0	0	0	0	0	0	1	50.00	.02000	1
45	0	.00	1	0	0	0	0	0	0	1	50.00	.02000	0
46	0	8.50	0	1	0	0	0	0	1	0	17.40	.05747	0
47	0	3.50	0	0	1	0	0	0	1	0	17.40	.05747	0
48	0	3.50	0	1	0	0	0	1	0	0	80.00	.01250	0
49	0	5.00	0	1	0	0	0	0	1	0	63.80	.01567	0
50	0	4.50	0	1	0	0	0	0	1	0	6.30	.15873	0
51	0	4.00	0	1	0	0	0	1	0	0	30.00	.03333	0
52	0	9.00	0	1	0	0	0	0	1	0	10.00	.10000	0
53	0	3.50	0	1	0	0	0	1	0	0	120.00	.00833	0
54	0	3.00	0	1	0	0	0	0	1	0	460.00	.00217	0
55	0	3.00	1	0	0	0	0	0	1	0	10.00	.10000	0
56	0	3.50	0	0	1	0	0	0	1	0	800.00	.00125	0
57	0	6.50	0	0	1	0	0	0	1	0	1700.00	.00059	0
58	0	.00	0	0	1	0	0	0	1	0	400.00	.00250	0
59	0	9.00	0	0	1	0	0	0	1	0	390.00	.00256	0
60	0	6.00	0	0	1	0	0	0	1	0	1200.00	.00083	0
61	0	8.00	0	0	1	1	0	0	0	0	100.00	.01000	0
62	0	8.00	0	0	1	0	0	0	0	1	400.00	.00250	0
63	0	7.00	0	0	1	1	0	0	0	0	400.00	.00250	1
64	0	8.50	0	0	1	0	0	1	0	0	1200.00	.00083	1
65	0	5.00	0	0	1	0	0	1	0	0	80.00	.01250	1
66	0	5.00	1	0	0	0	0	0	1	0	1500.00	.00067	0
67	0	.00	1	0	0	0	1	0	0	0	1500.00	.00067	0
68	0	3.00	1	0	0	0	0	0	1	0	2500.00	.00040	0
69	0	.00	1	0	0	0	0	0	1	0	50.00	.02000	0
70	0	4.00	1	0	0	0	0	1	0	0	600.00	.00167	1
71	0	7.50	1	0	0	0	0	1	0	0	1200.00	.00083	1
72	0	3.50	0	0	1	1	0	0	0	0	100.00	.01000	0
73	0	6.50	0	0	1	0	0	0	1	0	1400.00	.00071	0
74	0	8.00	0	0	1	0	0	0	0	1	5.00	.20000	0
75	0	5.50	0	0	1	0	0	0	0	1	5.00	.20000	0
76	0	4.00	0	0	1	0	0	0	1	0	25.00	.04000	0
77	0	5.50	0	0	1	0	0	0	1	0	680.00	.00147	0
78	0	7.50	0	0	1	0	0	0	1	0	1500.00	.00067	0
79	0	3.00	0	0	1	0	0	0	1	0	1400.00	.00071	0
80	0	10.00	1	0	0	0	1	0	0	0	60.00	.01667	1
81	0	6.00	1	0	0	0	1	0	0	0	60.00	.01667	0
82	0	8.00	0	1	0	1	0	0	0	0	125.00	.00800	1
83	0	6.00	0	0	1	0	0	1	0	0	28.00	.03571	0
84	1	4.50	0	0	1	0	0	0	1	0	560.00	.00179	0
85	0	5.00	1	0	0	1	0	0	0	0	30.00	.03333	0
86	0	4.50	1	0	0	0	0	1	0	0	5000.00	.00020	1
87	0	2.50	1	0	0	0	0	1	0	0	5300.00	.00019	0

OBS	USE	EXPA	FEDHOM	FEDFLD	STATEREG	RESDVL	RESPLN	ENVREG	RESMGT	SCINV	BUDGET	IBUDGET	ENGHY
88	0	.00	1	0	0	0	1	0	0	0	180.00	.00556	1
89	1	5.50	1	0	0	0	1	0	0	0	130.00	.00769	1
90	0	.00	1	0	0	1	0	0	0	0	300.00	.00333	1
91	1	8.00	1	0	0	0	1	0	0	0	60.00	.01667	0
92	1	5.00	1	0	0	1	0	0	0	0	25.00	.04000	0
93	0	.00	1	0	0	1	0	0	0	0	60.00	.01667	0
94	0	3.50	1	0	0	0	1	0	0	0	60.00	.01667	0
95	1	11.50	1	0	0	1	0	0	0	0	7000.00	.00014	1
96	0	8.00	1	0	0	1	0	0	0	0	7000.00	.00014	1
97	1	2.50	0	0	1	0	0	0	0	1	30.00	.03333	0
98	1	3.00	0	0	1	0	1	0	0	0	150.00	.00667	1
99	0	3.50	0	1	0	0	0	0	0	1	2000.00	.00050	1
100	0	2.00	0	1	0	0	0	0	1	0	325.00	.00308	0
101	1	4.00	0	1	0	0	1	0	0	0	1100.00	.00091	0
102	1	3.50	0	1	0	0	0	0	1	0	480.00	.00208	0
103	0	8.00	0	0	1	0	0	0	0	1	250.00	.00400	0
104	0	3.00	0	0	1	0	0	1	0	0	3000.00	.00033	0
105	0	.00	0	1	0	0	0	0	0	1	95.00	.01053	0
106	1	.00	0	0	1	0	0	0	1	0	75.00	.01333	1
107	0	4.50	0	0	1	0	0	0	1	0	3000.00	.00033	0
108	0	8.00	0	0	1	0	0	1	0	0	1200.00	.00083	0
109	0	8.00	1	0	0	0	0	0	0	1	1200.00	.00083	0
110	0	9.50	1	0	0	0	0	1	0	0	200.00	.00500	0
111	1	3.50	1	0	0	0	0	0	0	1	130.00	.00769	0
112	0	6.50	1	0	0	0	0	0	0	1	2000.00	.00050	0
113	0	4.50	1	0	0	0	0	0	1	0	420.00	.00238	0
114	0	3.00	0	1	0	0	0	0	1	0	3.00	.33333	1
115	0	.00	0	1	0	0	0	0	1	0	50.00	.02000	0
116	0	.00	0	1	0	0	0	1	0	0	120.00	.00833	0
117	0	10.00	1	0	0	0	0	1	0	0	1000.00	.00100	0
118	0	2.50	0	1	0	0	0	0	1	0	120.00	.00833	0
119	0	8.00	0	1	0	0	0	0	0	1	600.00	.00167	1
120	0	5.50	0	1	0	0	0	0	1	0	120.00	.00833	0
121	1	4.00	1	0	0	0	0	0	1	0	700.00	.00143	1
122	1	6.00	0	1	0	0	0	0	0	1	2500.00	.00040	1
123	0	.00	0	1	0	0	0	0	1	0	120.00	.00833	0
124	1	1.00	0	1	0	0	0	0	0	1	25.00	.04000	0
125	1	8.50	0	1	0	0	0	0	1	0	43.00	.02326	0
126	0	8.00	0	1	0	0	0	0	0	1	100.00	.01000	0
127	0	6.00	0	0	1	0	0	0	1	0	800.00	.00125	0
128	0	3.50	0	0	1	0	0	0	1	0	120.00	.00833	0
129	0	.00	0	0	1	0	0	0	1	0	800.00	.00125	0
130	0	5.50	0	0	1	0	0	0	1	0	15.00	.06667	1
131	1	3.50	1	0	0	0	0	0	1	0	200.00	.00500	1
132	0	2.00	1	0	0	0	0	0	0	1	2200.00	.00046	0

OBS	USE	EXPA	FEDHOM	FEDFLD	STATEREG	RESDVL	RESPLN	ENVREG	RESMGT	SCINV	BUDGET	IBUDGET	ENGHY
133	0	2.00	1	0	0	0	0	0	1	0	1100.00	.00091	0
134	1	9.00	1	0	0	0	1	0	0	0	1100.00	.00091	0
135	1	3.00	1	0	0	0	0	0	1	0	1600.00	.00063	1
136	1	3.50	1	0	0	0	0	0	1	0	43.00	.02326	0
137	0	8.00	1	0	0	0	0	0	0	1	200.00	.00500	1
138	1	9.50	1	0	0	0	1	0	0	0	100.00	.01000	0
139	1	3.00	1	0	0	0	0	0	1	0	100.00	.01000	1
140	0	6.50	1	0	0	0	0	0	1	0	60.00	.01667	0
141	0	8.00	1	0	0	1	0	0	0	0	25.00	.04000	0
142	0	2.00	1	0	0	0	0	0	1	0	7.50	.13333	1
143	0	.00	1	0	0	0	0	0	1	0	5000.00	.00020	0
144	0	.00	1	0	0	0	0	0	1	0	3700.00	,00027	0
145	0	.00	1	0	0	0	0	0	1	0	500.00	.00200	0
146	0	7.50	1	0	0	0	0	1	0	0	8500.00	.00012	1
147	0	.00	1	0	0	0	0	1	0	0	200.00	.00500	0
148	0	2.50	1	0	0	0	0	1	0	0	200.00	.00500	0
149	1	1.50	1	0	0	0	0	1	0	0	400.00	.00250	0
150	0	10.00	1	0	0	0	0	1	0	0	130.00	.00769	0
151	1	3.50	1	0	0	0	0	0	1	0	130.00	.00769	1
152	0	3.50	0	0	1	0	0	0	0	1	1600.00	.00063	0

CHESAPEAKE BAY DRAINAGE SURVEY DATA (CONT)

OBS	SOCSI	PHYBIO	PABM	BUDP	PPP	AOP	ACTIVE	IACTIVE	RANK1	RANK2	RANK3	RANK4	RANK5
1	0	0	0	10	25	45	2.50	.4000	5	3	4	2	1
2	0	0	0	5	25	50	10.00	.1000	1	4	2	3	5
3	0	0	0	5	10	85	12.00	.0833	2	4	3	5	1
4	0	0	0	10	50	40	18.00	.0556	2	4	1	3	5
5	0	0	0	0	10	30	11.00	.0909	2	5	3	1	4
6	0	0	0	0	80	10	20.00	.0500	3	4	1	5	2
7	0	0	0	25	50	25	30.00	.0333	2	5	3	4	1
8	0	0	0	10	20	70	14.00	.0714	2	3	5	1	4
9	0	1	0	10	10	75	1.00	1.0000	5	4	1	2	3
10	0	1	0	20	20	40	22.00	.0455	4	1	2	5	3
11	0	0	0	20	20	40	5.00	.2000	3	1	2	5	4
12	0	1	0	10	10	50	22.00	.0455	2	4	1	5	3
13	0	1	0	5	10	75	16.00	.0625	2	5	3	1	4
14	0	0	0	10	10	80	8.00	.1250	4	2	5	3	1
15	0	0	1	10	50	0	17.00	.0588	2	5	1	4	3
16	0	0	0	10	10	70	16.00	.0625	1	4	3	5	2
17	0	0	0	10	10	90	12.50	.0800	2	3	4	5	1
18	0	1	0	5	0	85	10.00	.1000	2	3	5	4	1
19	0	1	0	10	40	40	6.00	.1667	2	3	4	1	5
20	0	1	0	10	20	30	14.00	.0714	4	5	2	3	1
21	0	1	0	1	15	79	12.00	.0833	2	4	3	1	5
22	0	0	0	10	15	75	15.00	.0667	3	4	5	1	2
23	0	1	0	10	0	0	5.00	.2000	3	4	5	2	1
24	0	1	0	5	5	10	9.00	.1111	5	2	1	3	4
25	0	0	0	10	10	0	17.00	.0588	3	2	1	4	5
26	0	0	0	5	5	0	7.00	.1429	2	3	1	4	5
27	0	0	0	20	35	45	30.00	.0333	3	4	5	2	1
28	0	0	1	10	20	60	13.00	.0769	1	5	2	3	4
29	0	0	0	5	25	70	24.00	.0417	2	3	4	5	1
30	0	1	0	20	30	49	20.00	.0500	2	1	3	4	5
31	0	1	0	0	30	40	20.00	.0500	3	4	1	5	2
32	0	1	0	10	15	70	7.00	.1429	4	1	2	3	5
33	0	0	0	15	20	50	23.00	.0435	2	3	4	1	5
34	1	0	0	5	5	90	24.00	.0417	2	3	5	4	1
35	0	0	0	5	5	90	10.00	.1000	3	4	2	5	1
36	0	0	0	5	0	75	20.00	.0500	1	5	2	3	4
37	1	0	0	10	10	80	10.00	.1000	2	1	4	3	5
38	0	0	1	25	25	25	1.50	.6667	2	3	4	5	1
39	0	1	0	10	15	50	5.00	.2000	2	5	1	3	4
40	0	1	0	10	25	40	8.00	.1250	2	3	1	4	5
41	0	1	0	0	95	5	18.00	.0556	4	5	3	1	2
42	0	1	0	10	20	60	14.00	.0714	2	1	4	3	5

OBS	SOCSI	PHYBIO	PABM	BUDP	PPP	AOP	ACTIVE	IACTIVE	RANK1	RANK2	RANK3	RANK4	RANK5
43	0	0	0	3	10	80	30.00	.0333	1	4	3	5	2
44	0	0	0	0	0	100	12.00	.0833	5	3	1	4	2
45	0	1	0	0	20	0	5.00	.2000	2	4	1	3	5
46	0	1	0	5	5	95	10.00	.1000	3	5	4	1	2
47	0	0	1	5	15	80	14.00	.0714	2	4	3	5	1
48	0	1	0	30	10	55	22.00	.0455	2	3	5	4	1
49	0	1	0	10	40	50	15.00	.0667	2	4	3	5	1
50	0	1	0	10	0	100	13.00	.0769	2	5	3	4	1
51	0	1	0	15	20	55	20.00	.0500	4	1	2	3	5
52	0	1	0	5	15	65	30.00	.0333	4	2	3	1	5
53	0	1	0	0	0	100	2.00	.5000	1	4	3	2	5
54	0	1	0	0	20	80	19.00	.0526	3	1	4	5	2
55	0	1	0	5	20	70	10.00	.1000	3	2	4	1	5
56	0	1	0	0	0	100	35.00	.0286	2	4	5	3	1
57	0	1	0	5	30	65	8.00	.1250	1	4	5	3	2
58	0	1	0	10	60	20	9.00	.1111	4	1	3	2	5
59	0	1	0	5	10	85	15.00	.0667	5	4	3	1	2
60	0	1	0	10	20	60	21.00	.0476	2	3	4	5	1
61	0	0	1	5	45	5	12.00	.0833	4	1	3	5	2
62	0	1	0	30	10	50	5.00	.2000	1	3	2	4	5
63	0	0	0	15	20	50	14.00	.0714	4	3	5	1	2
64	0	0	0	10	0	90	13.00	.0769	5	2	1	4	3
65	0	0	0	10	10	50	12.00	.0833	2	1	4	5	3
66	0	1	0	10	30	50	15.00	.0667	2	3	4	5	1
67	0	1	0	0	15	85	8.00	.1250	2	5	1	4	3
68	0	1	0	5	20	60	26.00	.0385	2	4	3	5	1
69	0	1	0	5	5	90	33.00	.0303	2	1	4	3	5
70	0	0	0	10	20	50	30.00	.0333	2	3	4	5	1
71	0	0	0	10	50	10	24.00	.0417	5	4	3	1	2
72	0	0	1	5	0	100	10.00	.1000	2	5	3	4	1
73	0	0	1	10	10	70	2.00	.5000	4	2	1	3	5
74	0	1	0	5	10	75	27.00	.0370	4	3	2	5	1
75	0	1	0	5	5	85	28.00	.0357	4	3	5	2	1
76	0	1	0	0	70	30	4.00	.2500	2	3	4	5	1
77	0	1	0	0	40	0	12.00	.0833	4	2	3	5	1
78	0	1	0	5	10	84	3.00	.3333	1	4	3	2	5
79	0	1	0	5	50	50	1.00	1.0000	2	3	5	1	4
80	0	0	0	5	0	100	8.00	.1250	1	5	4	2	3
81	0	1	0	5	85	5	15.00	.0667	2	3	4	5	1
82	0	0	0	10	10	80	28.00	.0357	1	3	2	4	5
83	0	1	0	5	15	75	15.00	.0667	1	5	4	3	2
84	0	1	0	10	20	70	1.00	1.0000	2	4	3	1	5
85	0	1	0	0	20	70	29.00	.0345	5	3	4	2	1
86	0	0	0	5	10	80	31.00	.0323	1	3	2	5	4
87	0	1	0	0	45	45	11.00	.0909	4	3	1	2	5

OBS	SOCSI	PHYBIO	PABM	BUDP	PPP	AOP	ACTIVE	IACTIVE	RANK1	RANK2	RANK3	RANK4	RANK5
88	0	0	0	5	60	40	20.00	.0500	2	3	1	4	5
89	0	0	0	5	80	10	20.00	.0500	3	4	5	1	2
90	0	0	0	5	5	25	8.00	.1250	2	3	1	5	4
91	0	1	0	10	15	75	10.00	.1000	3	4	2	5	1
92	0	1	0	5	10	65	36.00	.0278	2	1	3	4	5
93	1	0	0	0	5	90	11.00	.0909	2	1	4	5	3
94	1	0	0	0	0	80	20.00	.0500	5	2	4	1	3
95	0	0	0	3	90	3	30.00	.0333	3	4	5	2	1
96	0	0	0	3	0	0	20.00	.0500	3	4	5	2	1
97	0	1	0	0	25	75	20.00	.0500	4	3	2	1	5
98	0	0	0	0	5	0	20.00	.0500	2	1	3	5	4
99	0	0	0	15	40	20	22.00	.0455	4	2	3	1	5
100	0	1	0	0	30	20	5.00	.2000	2	5	4	3	1
101	0	1	0	10	20	65	26.00	.0385	3	2	1	5	4
102	1	0	0	10	10	60	10.00	.1000	2	5	3	4	1
103	0	1	0	10	10	70	39.00	.0256	4	3	1	2	5
104	0	0	1	5	10	80	15.00	.0667	4	1	2	3	5
105	0	1	0	15	15	20	25.00	.0400	2	4	3	5	1
106	0	0	0	5	10	75	18.00	.0556	2	1	3	5	4
107	0	1	0	5	5	80	5.00	.2000	5	3	2	1	4
108	0	1	0	5	5	80	7.00	.1429	4	3	5	2	1
109	0	1	0	30	40	30	22.00	.0455	2	4	3	5	1
110	0	1	0	0	20	70	14.00	.0714	5	4	3	2	1
111	0	1	0	0	0	0	17.00	.0588	2	3	4	1	5
112	0	1	0	25	25	0	20.00	.0500	4	5	3	1	2
113	0	0	1	5	15	75	5.00	.2000	3	2	4	5	1
114	0	0	0	5	90	5	15.00	.0667	4	2	5	1	3
115	0	1	0	0	25	50	20.00	.0500	2	3	4	1	5
116	0	1	0	0	0	100	12.00	.0833	2	4	3	5	1
117	0	1	0	10	20	70	2.00	.5000	2	4	3	5	1
118	0	1	0	10	15	75	10.00	.1000	2	4	3	5	1
119	0	0	0	10	40	40	8.00	.1250	2	1	4	3	5
120	0	1	0	.5	1	98	12.00	.0833	4	3	5	2	1
121	0	0	0	5	10	80	25.00	.0400	1	4	5	3	2
122	0	0	0	30	30	40	22.00	.0455	2	4	1	3	5
123	0	1	0	0	20	80	1.00	1.0000	2	3	4	1	5
124	0	1	0	10	20	0	15.00	.0667	5	1	3	4	2
125	1	0	0	10	40	50	10.00	.1000	4	1	2	3	5
126	0	1	0	0	30	10	6.00	.1667	4	2	1	3	5
127	0	1	0	10	5	80	20.00	.0500	3	2	1	4	5
128	0	1	0	20	30	50	6.00	.1667	2	4	3	1	5
129	0	1	0	5	10	60	10.00	.1000	4	5	2	1	3
130	0	0	0	20	10	70	2.00	.5000	3	4	2	5	1
131	0	0	0	20	20	60	28.00	.0357	4	3	2	1	5
132	0	1	0	10	10	0	32.00	.0313	4	5	1	3	2

OBS	SOCSI	PHYBIO	PABM	BUDP	PPP	AOP	ACTIVE	IACTIVE	RANK1	RANK2	RANK3	RANK4	RANK5
133	0	1	0	10	2	85	20.00	.0500	2	5	4	3	1
134	0	1	0	10	30	40	10.00	.1000	3	1	2	4	5
135	0	0	0	10	30	60	26.00	.0385	5	3	2	4	1
136	0	1	0	0	50	50	20.00	.0500	4	1	2	3	5
137	0	0	0	0	0	40	30.00	.0333	3	2	4	1	5
138	0	1	0	30	20	35	11.00	.0909	5	3	4	2	1
139	0	0	0	10	25	60	20.00	.0500	2	3	1	4	5
140	0	1	0	5	10	85	20.00	.0500	4	1	2	3	5
141	0	1	0	1	5	89	27.00	.0370	3	4	5	2	1
142	0	0	0	5	35	30	3.00	.3333	3	2	5	4	1
143	0	1	0	5	20	45	15.00	.0667	3	5	1	4	2
144	1	0	0	5	10	10	1.00	1.0000	5	4	3	2	1
145	1	0	0	10	10	80	1.00	1.0000	2	5	4	3	1
146	0	0	0	20	20	60	27.00	.0370	2	5	3	4	1
147	0	0	1	0	50	30	5.00	.2000	5	2	1	3	4
148	1	0	0	0	0	25	1.00	1.0000	2	5	3	4	1
149	0	0	1	10	10	70	11.00	.0909	3	4	1	2	5
150	1	0	0	10	20	40	8.00	.1250	2	5	4	1	3
151	0	0	0	0	0	100	20.00	.0500	2	1	5	4	3
152	0	0	1	0	50	0	8.00	.1250	2	1	3	4	5

NOTE: RANK1 - RANK5 REPRESENT INDIVIDUAL RANKINGS OF INFORMATION PACKAGES.
(EX. RANK1 = 4 INDICATES THAT INFORMATION PACKAGE FOUR WAS MOST PREFERRED.)

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The two page vita has been removed from the scanned document. Page 2 of 2