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SEA GRANT DELPHI EXERCISES: TECHNIQUES FOR UTILIZING INFORMED JUDGMENTS OF A MULTIDISCIPLINARY TEAM OF RESEARCHERS

by

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BACKGROUND OF THIS PAPER

This paper is based on research done at the Bureau of Business Research, Graduate School of Business Administration, University of Michigan, in support of the Regional Economics and Water Resource Management project of the Sea Grant Program at the University of Michigan.

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I

Introduction

Forecasting is an integral part of planning. A forecast should:

- Anticipate what occurrences are possible and assess their probabilities.
- Assess the interactions (cross-impacts) among these occurrences.
- Identify the occurrences that can be controlled and the extent of such control.
- Evaluate alternative future possibilities, considering varying degrees of intervention that are within our power to control.
- Convert these outcomes into displays that provide us with an assessment of the impact of the possible future.[1/]

The objective of this paper is to present a plan for using modified Delphi techniques--essentially a method for securing informed judgments of a group of experts--to secure the use of the competences of a multi-disciplinary team of researchers in forecasts related to planning for a representative region in the Great Lakes area. These forecasts will emphasize the consequences of regional planning on marine resources

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1/ Selwyn Enzer, "A Case Study Using Forecasting as a Decision-making Aid," IFF Working Paper, WP-2, Middletown, Conn., Institute for the Future, Dec., 1969.

4. The improvement of communications among a multi-disciplinary team of researchers, many of whom are accustomed to operating independently or within the boundaries of individual disciplines

Experiments have shown that feedback and reassessment quite often result in convergence of opinions, as common elements of judgment are reinforced, ambiguities resolved, extreme positions clarified, and the impact of related events assessed. The refinement and strengthening of a consensus are especially important in regional planning, which is essentially a political process. But feedback and reassessment of informed judgments can be tremendously valuable even if it does not lead to convergence.

II

Background of the Sea Grant Delphi Exercises

The Sea Grant Program

The Congressional mandate in the Sea Grant Act calls for both the development of marine resources for economic and social benefits to the nation and for the education and training of personnel to carry out such development. Integral to the program is the communication of useful information to the various marine communities with an interest in marine resources.

The Sea Grant Program of the University of Michigan is designed to (1) establish standards of expertise and a center of knowledge for

Great Lakes research, and (2) provide useful information as a service to regional planners and decision makers. Predictive models are to be used as a focusing device to bring together experts who are competent in diverse fields and organize their knowledge to provide analytical assistance in the design of a comprehensive planning system for dealing with marine resource problems and opportunities.

The program strategy is to concentrate initially on a discrete subregion within the Great Lakes area, not only to avoid widely diffused research but to provide experience in coupling field research with systems analysis and model development. A feedback process is to be developed so that field research stimulates modeling, and the model in turn defines priorities for acquisition of additional field data. The Grand Traverse Bay Area[2/] was selected because it is a reasonable physical analogue to Lake Michigan, the next subsystem of concern, and representative of many areas in the Great Lakes region where the economic development and quality of life are closely related to water resources.

Although a considerable amount of empirical data is being developed in the Regional Economics program and other Sea Grant projects, judgments form the best source of insight into the future. The development of a method to obtain and refine informed judgments of knowledgeable people

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2/ For this research the Grand Traverse Bay Region is considered to be the following ten counties which make up the Region 10 of the State of Michigan's planning and development regions. These counties are Emmet, Charlevoix, Antrim, Kalkaska, Grand Traverse, Benzie, Manistee, Wexford, and Missaukee.

is one of the most challenging problems in the task of improving decision making and planning. The need is particularly crucial in the Sea Grant Program, where the decision maker must consider the opinions of a multidisciplinary team of advisers--some of them experts in extremely specialized areas, while the competence and experience of others span a wide range of technical, economic, social, legal, and political matters--and where precise quantification and models for combining judgments are lacking.

In spite of the importance of intuition and judgment there are inherent dangers in relying on the judgments of a single expert who will tend to view a problem in terms of the boundaries of his own expertise, even though his is only one of several disciplines bearing on the issue. The performance of the expert should improve when he can interact with other experts in the same or related fields. However, the use of a committee to effect the interaction introduces some serious administrative, logistical, sociological, and psychological barriers. The output is likely to be a compromise weighted toward the opinions of those in the group who are most articulate, most prominent, or better placed administratively.

The Delphi method

The Delphi techniques, developed by researchers of the RAND Corporation, provide an initial step toward a systematic use of expert opinion and they appear to have a flexibility that would allow for a much

wider use than the published applications indicate.[3/] The basic features of the method include anonymous responses, iteration, numerical estimates, statistical group summaries, controlled feedback, and reassessment. The means which they provide for obtaining informed judgments preserves the desirable characteristics of face-to-face group deliberations while overcoming some of the associated psychological and administrative barriers. The method yields a cumulative assessment of the group's anticipations without requiring elaborate investigations and support of each issue under consideration.

The objective of the method is to obtain from a group of experts the most reliable consensus of opinion through anonymous responses to a carefully designed program of sequential interrogations. The techniques can be modified to exploit the talents of a well-informed multidisciplinary team of experts by securing judgments that are weighted to reflect specialized competence and, using the combined insight of the group, to interpret those judgments for regional planners and decision makers.

The information exchange is accomplished through a series of

3/ Initially the studies were under the guidance of Dr. Norman Dalkey and Dr. Olaf Helmer. For background information on the Delphi techniques, modifications, and applications see: John D. Ludlow, "The Delphi Method: A Systems Approach to the Utilization of Experts in Technological and Environmental Forecasting," Working Paper No. 3, Bureau of Business Research, Graduate School of Business Administration, University of Michigan, Ann Arbor, Michigan, March 24, 1970.

information packages referred to as rounds. The opening rounds are controlled brainstorming sessions in which a respondent is encouraged to present developments in his area of expertise which he feels will be important for a specific issue or topic. The feedback of responses from other informed people serves to stimulate him to consider developments in his own or related areas that he may have inadvertently neglected. To facilitate the initial exchange of information and to focus on common measures of values in developing and presenting a viewpoint that may be difficult to articulate, respondents attach numerical estimates to a list of important events developed by the group. Self-appraisal indexes are provided to permit the respondent to indicate his relative competence in specific issues and his familiarity with the region. Desirability and feasibility indexes can be designed to account for the value judgments of the estimators and the relative influence of technical, social, economic, and political factors. These serve to help the expert in making his judgment and the rest of the panel in interpreting them.

III

Research Needs

Although the initial focus of the Sea Grant Program is on a discrete subregion, its main concern is to develop techniques that will be useful in designing a comprehensive planning system for the management of the marine resources of the whole Great Lakes Basin.

The Delphi method will be employed in several roles that represent essentially new applications. At a recent conference recognized experts

in forecasting and planning[4/] were in agreement that the hierarchy of planning levels is best expressed by the basic three-level concept of policy planning, strategic planning, and tactical planning. Thus far the Delphi method has been employed primarily to obtain and refine the long-range forecasts associated with strategic planning. Sea Grant experts see their task not only as providing the basis for forecasting alternative futures for a region but as also assisting in "creating the future," and their combined judgments should be brought to bear also at the normative (policy formulation) level and at the operational level of planning. This will be attempted in the Sea Grant Delphi exercises.

The panels will be asked to make value judgments. Dalkey indicates that in making value judgments the validity of Delphi procedures--in the sense of the willingness of respondents to furnish lists of objectives or goals, to allocate weights, to accept a statistical aggregation of weights supplied by a group, and to reassess their judgments based upon feedback of information supplied by the group--is much more obscure than in factual judgments.[5/]

Several techniques for improving the estimating process will also be tested. A concern in securing personal probability assessments is

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4/ Erich Jantsch, Perspectives of Planning (Paris: Organization for Economic Cooperation and Development, 1969).

5/ Norman C. Dalkey, The Delphi Method: An Experimental Study of Group Opinion, Memorandum RM-5888-PR (Santa Monica, Calif.: RAND Corp., June, 1969).

that they correspond with the assessor's judgment (i.e., that he doesn't violate the postulates of coherence). The communication problem is compounded when individual distributions are combined into a single distribution representing a consensus of judgments and presented to a decision maker who must interpret it. To gain insight into the nature of the problem, numerical probabilities will be compared with associated verbal phrases. The Delphi techniques of numerical estimates, feedback of group responses, and reassessment will be employed to develop an ordered scale of verbal phrases, generally comparable to commonly used numerical probabilities. The verbal phrases may be more appropriate in estimating social developments where the use of numerical estimates tends to give an exaggerated, and consequently a somewhat less credible impression of precision.

Another vexing problem associated with personal probability estimates is the assumptions the estimator makes about the future environment. There is a proposed remedy which is procedural: the attention of the panel is first focused on the technical environment and the political, social, institutional and other environmental factors are assumed to develop along present trends. Subsequently, a broader perspective is taken and the influences of the other environmental factors and the value judgments of the estimator are taken into account by using such measures as desirability, feasibility, and importance indexes, developed for various time periods and from a personal as well as a societal orientation. These indexes assist the estimator in

making his judgments and the other panel members in interpreting and weighting them. Techniques for exploiting the use of conditional probability estimates will be examined by the program administrator.

The administrative procedures are flexible enough to incorporate further refinements as the exercises progress.

IV

Methodology

Overall research design

The design of this exploratory research is depicted in Figure 1. In preparation for the Delphi exercises a study was made to determine which technical, social, economic, and political issues might have a significant impact on the region's marine resources.

A progressive type of Delphi method will be attempted in which a list of pertinent developments in the technical environment will be generated and assessed by a technical panel before the important societal developments are considered by broader multidisciplinary panels. The prior consideration by a technical panel simplifies the problems of making estimates based on assumptions about the total future environment, avoids bogging down the panel members with data and directs their attention to areas where their interest and expertise lie.

Many of the panel members selected should be experienced in the technology of waste water treatment and disposal and also familiar with the Grand Traverse Bay area. The self-appraisal and importance indexes

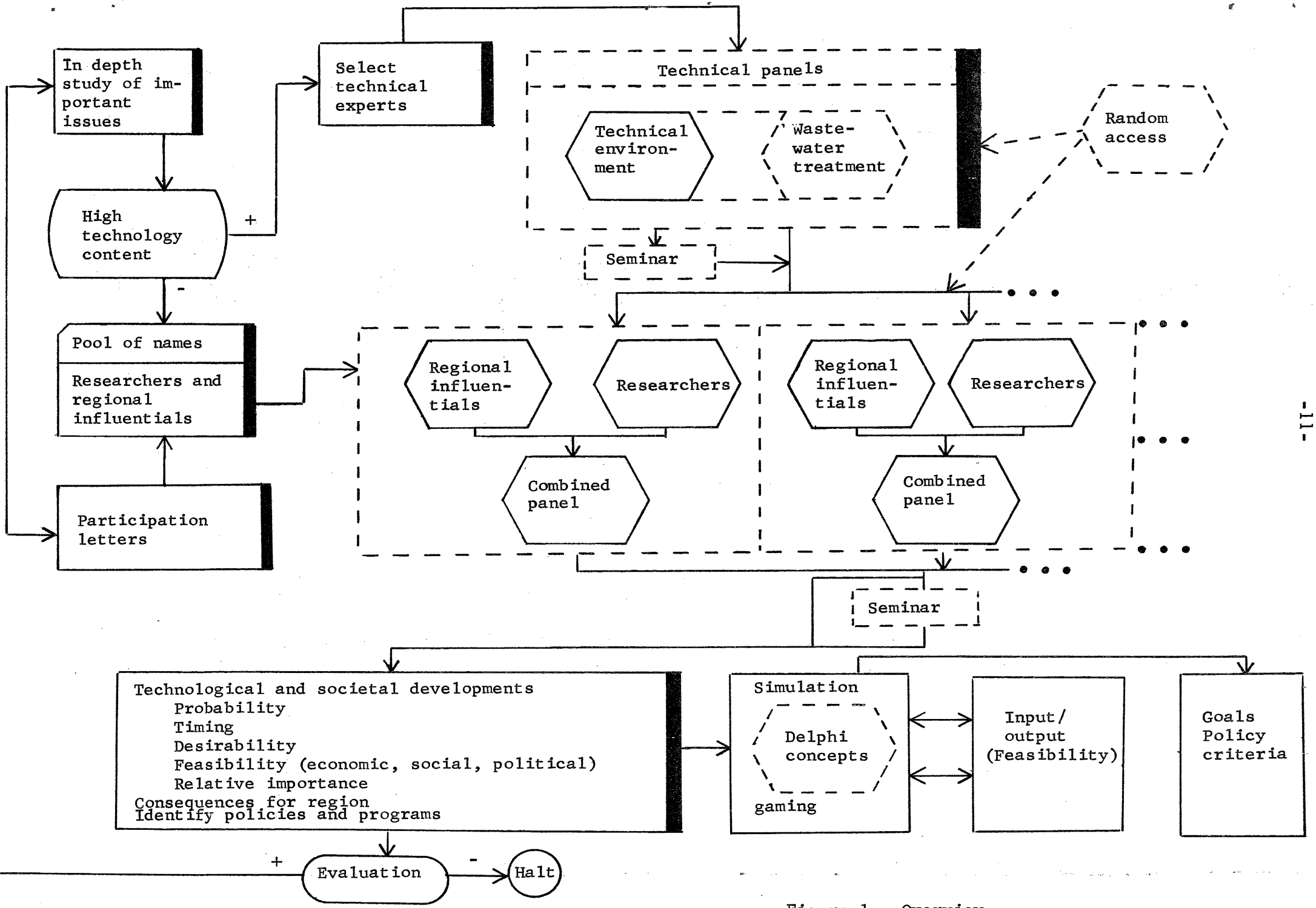

Figure 1. Overview.

will provide a mechanism for developing a subgroup, competent and interested in waste water treatment and disposal, and thus provide an opportunity for gaining a level of specificity consistent with operational planning while considering related factors in the larger technical environment. Increased benefits from the exercises can be realized if a seminar is held to review the output of the technical panel.

The broader panels will consider the judgments of the technical panels as well as other technical and societal developments. Regional planners and decision makers will be invited to participate along with Sea Grant researchers. The panels will be balanced so far as is practicable in terms of experience, age, sex, and so on, and several panels will be conducted concurrently to check the methodology for consistency.

If the results justify it, a seminar will be held to review the output of the exercises.

The Delphi exercises together with forecasts based on methods and information from other Sea Grant projects will provide information for developing alternative scenarios for the Grand Traverse Bay region. These scenarios can be subjected to gaming and simulation during which the Delphi concepts of dynamic feedback and reassessment can be used to evaluate the impact of various forms of intervention and to develop strategies as well as to generate exogenous technological and societal developments. The alternative futures developed could be tested for feasibility in relation to the state or national environment.

Flexibility can be incorporated in the Delphi exercises so that the information exchange can be extended to other interested individuals

or groups on a random access basis. Evaluation and modification of the methodology to satisfy Sea Grant requirements will be conducted almost continuously.

Technical panels

There are expected to be about 25 experts participating in the technical panel with a subpanel knowledgeable in waste water treatment and disposal formed from the group on the basis of self-appraisal and importance indexes. Candidates for the technical panel will be contacted personally to insure that objectives and procedures are understood and that all relevant disciplines are very likely to be represented throughout the period of information exchange. This direct contact is also desirable since it is intended that the initial administrative procedures will be quite flexible.

The immediate objectives of the technical panel exercises are to use informed expert judgment to:

1. Establish consensus on the relative importance of pollution sources for Grand Traverse Bay and their potential for abatement
2. Obtain the insight of technical experts into the marine resource problems and opportunities of the Grand Traverse Bay area
3. Generate a list of technological developments that would be important for the area

4. Determine the probability, timing, desirability, and feasibility of these developments
5. Establish a subpanel of experts knowledgeable in the technology of waste water treatment and disposal and use their judgments to develop:
   a. Weighted alternative approaches to waste water treatment and disposal
   b. Research and informational references
   c. Research and informational needs

The essence of the Delphi method and modifications can best be illustrated by going through a series of sequential interrogations or rounds. Representative forms and responses are attached to this working paper (Figures 2-11).

Round 1

Each participant is sent a package of general background information and estimating forms for (1) sources of pollution and specific pollutants, and (2) important technical developments relating to water resources. (See Figures 2, 3, and 4).

It is desirable that the respondents volunteer most of the information that will be part of a combined list of events that will be fed back to them on subsequential rounds and narrowed on the basis of group judgments regarding importance and uncertainty. However, the administrator, with his technical consultants, should be prepared on subsequent rounds to interject some events for consideration by the

panel if an area of interest is not satisfactorily covered by unaided responses. The technical developments and sources of pollution are elicited on estimating forms designed to familiarize the panel with the estimating procedures and to minimize the inclusion of trivial events and those that cannot be subjected to the desired specific quantitative estimates. Definitions associated with the estimating factors for the early rounds are attached to the estimating forms (Figure 5).

The questionnaires are returned to an administrative assistant (in the Sea Grant Advisory Office) who records their arrival and insures that only a panel member's number is on the completed forms. He then turns them over to the chief investigator who, using technical consultants, will collate and edit them to eliminate duplications, combine similar events, and retain only discrete events and consistent technical references.

Round 2

Each participant receives the edited list of events and pollution sources and is asked to make his assessments, bearing in mind the interrelationships of other events that the panel felt were important (Figures 6 and 7). He may also add other developments that he wishes the panel to consider. The first two rounds are designed as brain-storming procedures with the panel indicating acceptance or rejection of an idea by the numerical estimates which they assign.

The responses are summarized to indicate the median estimate of the group--and selected subgroups--and the spread of opinions. The range of the consensus can be specifically designated but generally

the interquartile range--the interval containing the middle 50 per cent of the responses--is considered to represent the thrust of the current consensus.

Round 3

Starting with this round and on subsequent rounds, the statistical summary of the previous round is presented to the panel members (Figures 8 and 9). Each respondent is asked to reassess his position on those events that the panel has decided are important and on which there exists a wide range of opinions, considering carefully the statistical summaries, prerequisite technological improvements, and the internal consistency of interrelated events. If his revised estimate falls outside the ranges indicated as the consensus for the previous round, he is asked to provide brief supporting arguments for this extreme position. These minority opinions together with specific questions directed to specific panel members--based on an analysis of their previous responses--are included in the summaries of subsequent rounds. Respondents may be asked to revise their judgments on specific events as the result of the administrator's indicating a delay in prerequisite technology or proposing a specific type of intervention, such as pollution control regulations. (See Figure 10.)

Those panel members who have indicated a competence and an interest in waste water treatment and disposal will be asked to indicate an order of preference for waste water and disposal systems for a region similar to the Grand Traverse Bay Region, to provide pertinent research

and literature references, and to list information needs and research priorities. All respondents will be asked to indicate what problems and opportunities they foresee for the region (Figure 11).

Fourth and subsequent rounds

The information provided by the group is fed back to the respondents who are asked to reassess their position on important events on which there is still no satisfactory consensus and to provide a weighting of preferred approaches to waste water treatment and disposal and problems and opportunities of the region.

If the results warrant, a seminar which could include regional planners and other interested people will be convened to discuss the results of the Delphi exercises.

Broad multidisciplinary panels

Panels of approximately 25 members will be selected from a pool of names drawn up from the responses to a participation letter sent to all researchers in the Sea Grant program and to planners and decision makers in the Grand Traverse Bay Region. Biographical information provided by the participation questionnaire will be the basis for balancing the panels.

The information exchange will be directed so that for the first two rounds participants from the region will constitute separate panels from the Sea Grant researchers. On subsequent rounds they will join together to comprise three combined panels. The output of the separate

and combined panels will be compared to check the consistency of the methodology.

The immediate objectives of the broader panels are to utilize informed expert judgments to:

1. Identify important technological and societal developments--in addition to those identified by the technical panel--that could influence regional planning in the next 20 years
2. Determine the probability, timing, desirability, feasibility, relative importance, and trends of these developments
3. Anticipate the probable impact of these technological and societal developments on the region
4. Identify the problems and opportunities for the region in the next ten years

The iterative feedback and reassessment techniques for the broader panels are similar to those employed by the technical panels. Some of the estimating procedures will be modified, however, to deal realistically with conceptual differences in anticipating future societal changes and forecasting technological progress.[6/]

6/ The comparison of expected technological and societal developments is based on information contained in: Raul de Brigard and Olaf Helmer, "Some Potential Societal Developments, 1970-2000," IFF Report R-7, Middletown, Conn., Institute for the Future, Apr., 1970.

In technological forecasting, technology is generally treated as an irresistible force which can be accelerated or decelerated by society, but cannot be stopped or reversed. The occurrence or nonoccurrence of societal developments, however, depends greatly on the nature of human intervention and both progress and regression are possible. In addition, the process of social change is far more complex and the vocabulary far less precise in the social sciences than in the hard sciences.

Some techniques will be explored to obtain and refine group judgments without giving an exaggerated impression of precision. One technique is to present graphically the historical trends of particular interest and ask the panel to extend the graphs through the forecasting period. Feasibility, desirability, and importance indexes, together with arguments advanced to support positions outside the median range, can be used to define a consensus which can be further refined through feedback and reassessment.

Another similar technique, which researchers at the Institute for the Future have used in a series of studies dealing with long-range forecasting of technological and societal events,[7/] is to elicit from the panel possible future societal developments which might occur in the forecasting period and which would represent changes from current patterns. Two nominative scales were used in those studies to indicate the importance

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7/ Ibid., p. 17.

and the strength of the trends. This technique will be modified in an attempt to avoid some of the ambiguities in scale and timing that were encountered.

The combined panels of planners and decision makers from the region and Sea Grant researchers will assess the impact on the Grand Traverse Bay region of the technological and societal developments which the technical panel or earlier rounds of the broader panel have described in terms of timing, desirability, feasibility (social, political, institutional, technical, economic), importance, and trend. And they will explore the feasibility of various forms of intervention to avoid undesirable consequences or to improve the likelihood of realizing opportunities.

In the Sea Grant exercises the Delphi techniques will be used in conjunction with other methods of obtaining group judgments including interviews and conferences or seminars to discuss the results of exercises and the effectiveness of methodological modifications.

V

Evaluation

Evaluating the effectiveness of the Delphi techniques in the Sea Grant exercises can be related conceptually to the test marketing of a new product--in this case the new product is a group of management techniques for obtaining a consensus of informed judgments.

Thus far, the Delphi method has received limited exposure which has been primarily among technically-oriented people. The Sea Grant

exercises will provide a unique opportunity for an evaluation of the method in an operational exercise with a much broader segment of talented people: noncaptive respondents and decision makers who have not had a key role in committing resources to the exercises or an active role in administering them. Even more important the participants will be particularly well qualified to criticize the techniques--they are not only concerned with the substantive results of the exercises but are dedicated to searching for improved methodologies and have a relatively keen awareness of the behavioral difficulties encountered in conventional approaches to group deliberations and assessments. Their recommendations could result in significant improvement and refinement of the method as well as wider applications.

FIGURES (2-11) AND APPENDIXES

These forms and figures are not necessarily those that will be used in the Sea Grant Delphi exercises but are given as examples of the type of information that will be contained in the early rounds.

TECHNICAL PANEL 1

PANEL MEMBER 01

INFORMATION PACKAGE ONE

This information package consists of:

1. A general socioeconomic summary of the area.

2. A general summary of marine resource problems and opportunities and alternatives in waste water collection, treatment and disposal.

3. Forms to be accomplished.

   a. sources of pollution
   b. important technical developments relating to water resources
   c. problems and opportunities for the region
   d. biographical information

Please submit your response as early as practical but no later than _____

To:

Delphi Exercises
Sea Grant Advisory Office

Figure 2. Information package for Round 1 of Delphi Technical Panel 1.

Round 1
Panel Member

Estimating Form (A); Important Developments

1. Self-evaluation (A). Familiarity with Grand Traverse Bay area (scale 1-5)---
2. List the developments that you feel will be important to the Marine resources of the area in the next 20 years. Indicate pre requisite technology associated with the developments.
3. Indicate with a check mark (✓) those developments closely related to wastewater treatment and disposal.
4. Evaluate all developments with respect to the factors on the right. The definition of factors and indexes are attached.

Developments	Related to Wastewater ✓	Self-evaluation (B) 1-5	Probability (1971-1980) 0-100	Technology is prerequisite to development (s) number(s)	Timing: Year by which the probability is x that the event will have occurred. x=.25	x=.50	x=.75	Remarks: Group developed verbal phases associated with numerical probabilities will be available on subsequent rounds. Remarks

Figure 3. Round 1 form for estimating important developments.

Round 1
Panel Member

Continuation of Estimating Form (A): Important Developments

List additional developments and evaluate with respect to the factors on the right.	Related to wastewater	Self-evaluation	Probability (1971-1980)	Tech. is prerequisite to development number(s)	Timing x=.25	Timing x=.50	Timing x=.75	Remarks
Developments		1-5	0-100					

Figure 3. (con't)

Round 1
Panel Member

Estimating Form (B): Sources of Pollution

Listed below are some potential sources of pollution to a body of water comparable to Grand Traverse Bay and some specific pollutants. The purpose of this estimating form is to develop a list of pollution sources and pollutants that in subsequent rounds will be presented in a Matrix Form which will permit judgments to be made as to the relative importance of pollution sources, the social and economic activities affected, and the technical and economic feasibility of making the associated problems more tolerable. A tentative Matrix to be used in round 2 is attached for your guidance and consideration.

Sources of Pollution

1. Effluent from Traverse City sewerage system
2. Septic tanks in the region
3. Storm water run off
4. Industrial wastes

You are requested to add others

Specific Pollutants

1. Phosphorus compounds
2. Nitrogen compounds
3. Oxygen consuming Organic matter
4. Bacteria viruses
5. Turbidity
6. Suspended solids

You are requested to add others

Figure 4. Preliminary form for establishing estimating matrix.

Definition of Estimating Factors and Indexes

Self-evaluation indexes -- scale 1 to 5

(a) Familiarity with the Grand Traverse Bay Region

Your estimate of your familiarity with the Grand Traverse Bay Region (the 10 county area shown in the information package)

1 = Totally unfamiliar with the region
2 = Casually acquainted with the region
3 = Well acquainted with a few aspects of the region
4 = Generally familiar with the region
5 = Actively studying the social and economic development of the region

(b) Familarity with the item being considered

Your estimate of your knowledge and comprehension of the specific development being considered in comparison to other researchers who are participating in the Sea Grant Program at the University of Michigan

1 = Unfamiliar
2 = Slightly familiar
3 = Generally acquainted
4 = Well acquainted with most aspects
5 = Expert or researcher working in the area

Feasibility indexes -- scale 1 to 5

(a) Technical feasibility

Your estimate of the technical difficulty in accomplishing the event. Assume a political and social environment which might evolve normally from present circumstances

1 = Extremely difficult
2 = Very difficult
3 = Moderately difficult
4 = Slightly difficult
5 = Routine development

Figure 5. Definition of estimating factors and indexes--early rounds.

Definition of Estimating Factors -- continued

(b) Economic feasibility

Your estimate of the economic reasonableness of accomplishing the event. Assume a political and social environment which might evolve normally from present circumstances

1 = Extreme subsidy required
2 = Moderate subsidy required
3 = Economic aspects are of minor concern
4 = Slightly attractive economically
5 = Economically attractive

Although the main focus of this panel is on technical performance, some developments will be highly dependent on economic considerations. For some of these developments technically trained individuals can best make the economic feasibility assessment.

Timing

In an attempt to reconcile variations in personal probability estimating routines and to further refine the consensus of informed judgments, you are asked to:

(a) Estimate the probability that the event will happen in the 1971-1980 time period
(b) Estimate the dates by which the probability is .25, .50, and .75 that the event will have occurred
(c) Indicate--by remarks--any significant discontinuities in your probability estimates
(d) Indicate numerical probability estimates for each of a list of probability-related words and phases. This is a one time requirement and is an attempt to develop verbal labels to a probability scale which can be used in estimating societal developments where numerical estimates could give an exaggerated impression of precision

Importance Index -- scale 1 to 10

Starting with the second round the events will be rated according to their importance to the exercise as judged by the panel. In subsequent rounds only "important" issues on which there is no reasonable consensus

Figure 5 (con't).

Definitions of Estimating Factors--continued

will be considered by the panel. After examining all events on the estimating form make a judgment as to the most important and least important and assign a value of 10 and 1 respectively. Then assign each of the other events values from 2 to 9 as you estimate their values relative to the most important and least important events. You may assign the same value of any number of events.

Personal Probability Assessments

Personal probability assessments are an important feature of the Delphi techniques. However, in estimating probabilities associated with social and political developments numerical scales give an exaggerated impression of precision. Therefore an attempt will be made to establish for each Delphi panel an ordered list of verbal phrases that corresponds generally to commonly used numerical probabilities. You are requested to assign a numerical probability from .00 to 1.00 to each of the following verbal phrases that intuitively express the notion of the likelihood of an event, for example: Likely = .70.

1. Highly probable =	___	11. Slight odds against =	___
2. Very likely =	___	12. Uncertain =	___
3. Very probable =	___	13. Somewhat unlikely =	___
4. Quite likely =	___	14. Fairly unlikely =	___
5. Good chance =	___	15. Rather unlikely =	___
6. Likely =	___	16. Not much chance =	___
7. Rather likely =	___	17. Improbable =	___
8. Better than even =	___	18. Quite unlikely =	___
9. Slight odds in favor =	___	19. Very unlikely =	___
10. Tossup =	___	20. Highly improbable =	___

Figure 5 (con't)

Select from the above list--or add your own--verbal phrases that best describe the following numerical probabilities.

.10	_____	.75	_____
.25	_____	.90	_____
.50	_____		

Figure 5 (con't).

Round 2
Panel Member

Estimating Form (A): Important Developments

1. Self-evaluation (A). Familiarity with Grand Traverse Bay Area (scale 1-5)----
2. Listed below are technical developments contributed by the panel as important to the marine resources of the area in the next 20 years. Add other events that you would like the panel to consider.
3. Evaluate all developments with respect to the factors on the right (economic feasibility only if pertinent). Indicate if an event is prerequisite to a listed event.

Technical Development	Self-evaluation	Importance	Feasibility: Technical	Feasibility: Economic (if pertinent)	Probability (1971-1980)	Event is a prerequisite to event	Timing: Year by which the probability is X that the event will have occurred. x=.25	Timing: x=.50	Timing: x=.75	Remarks: Probability Quantitative-verbal .25= .50= .75=
	1-5	1-10	1-5	1-5	0-100	No.				Remarks

Figure 6. Round 2 form for estimating important developments.

Round 2
Panel Member

Estimating Form B: Sources of Pollution

Listed below are some potential sources of pollution of Grand Traverse Bay and some specific pollutants.

1. Add others which you would like the panel to consider 2. Evaluate with respect to the factors on the right. Assume a social and political environment which is consistent with present trends	Self-Evaluation	Relative Importance		Abatement Feasibility		Specific Pollutants							Social and Economic Activities Affected
		1971-1980	1981-1990	Technical	Economic	Phosphorus	Nitrogen	Bacteria viruses	BOD	Turbidity	Suspended solids	Add Others	1. Recreation 2. Commercial fishing 3. Indus. water quality 4. Aesthetics 5. Public water supply List Others 6. 7. 8.
Description of Source	1-5	1-10	1-10	1-5	1-5	Source contributes what % of specific pollutant							List (by number) in order of importance
1. Effluent from Traverse City sewerage system (see definitions)													
2. Septic tanks in the region													
3. Storm water run off													
4. Industrial Wastes													
a. Food processing													
b. Other													
Estimates should sum to 100 →						100	100	100	100	100	100	100	100

Figure 7. Round 2 matrix for estimating pollution potentials.

SUMMARY OF GROUP RESPONSE

1. The following events will not be considered further by the panel because the panel has indicated that they are relatively unimportant.

2. The following events will not be considered further by the panel because a reasonably strong group consensus has been indicated.

3. You are asked to reassess your estimates of the remaining events on the basis of information supplied by your Delphi panel. Consider the interrelationships among events as well as the judgments of the other panel members.

Figure 8. Events relegated to background information based on importance and consensus.

SUMMARY OF GROUP RESPONSE

Event 1 OPERATIONAL PHYSICOCHEMICAL COAGULATION /ADSORPTION DIRECT TREATMENT

Panel and subpanels	No. of Resp's	Range*	Importance	Familiarity: Ev't	Familiarity: R'n	Feasibility: Tech	Feasibility: Econ	Probability (1971 1980)	1 Timing 1 9 (mediam .25, .50, and 9 7 .75 probabilities) 8 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5	Beyond 1985 (year in parenthesis)
Your estimate	-		2	3	6	5	1	.30	*	.50 (88) .75 (92)
Total Panel	25	U	7	7	7	7	6	.88		
		M	6	4	6	6	4	.72		
		L	1	1	1	2	1	.21		
Those who rated competence 4 or more	8	U	7	7	6	7	6	.90		
		M	6	6	6	6	4	.75		
		L	5	5	5	4	2	.25		
Civil Engineers	5	U	7	7	6	7	6	.90		
		M	7	6	6	6	5	.72		
		L	6	5	5	5	5	.47		

PREREQUISITE TECHNOLOGY:

SUPPORT FOR EXTREME POSITIONS:

DIRECTED QUESTIONS:

Event 2

Your Estimate									
Total Panel									

* U= upper quartile M=median L=lower quartile. The interquartile range--the interval containing the middle 50 per cent of the responses--is considered the current consensus.

0 If reassessed estimate is still outside of consensus range, submit brief supporting arguement for your position.

Figure 9. Example of a statistical summary.

Round 3
Panel Member Estimating Form (A) Important Developments

1. Self-evaluation (A). Familiarity with Grand Traverse Bay area (scale 1-5)--

2. Listed below are technical developments which the panel has judged important and on which a satisfactory consensus has not been obtained. You are asked to reassess your position, considering the attached statistical summaries and the internal consistency of inter-related events.

3. Evaluate all developments with respect to the factors on the right. If any revised estimate falls outside of the consensus ranges, as indicated on the attached summary, submit brief supporting arguement.

Technical Development	Self-evaluation	Importance	Feasibility: Tech	Feasibility: Econ (if pertinent)	Probability (1971-1980)	Timing: Year by which the probability is x that the event will have occurred: x=.25	x=.50	x=.75	Remarks: Probability Quantitative - Verbal: .25= .50= .75= / Supporting Arguements
	1-5	1-10	1-5	1-5	0-100				
1.									
2.									

Probability and timing of event No. if event No. does not occur.

Probability and timing of event No. if pollution control requirement becomes .

Figure 10. Round 3 form for estimating important developments.

Estimating Form C: Problems and Opportunities

List what you feel are the most important problems and opportunities in the Grand Traverse Bay Watershed Area related to its water resources. Be as specific as practicable. A combined and edited list of problems and opportunities will be fed back to the panel on the next round and estimating proceedures will be employed to establish their relative importance and impact on the region.

Figure 11. Form for developing an ordered list of problems and opportunities.

APPENDIX A

INITIAL MEMORANDUM TO TECHNICAL PANEL

MEMORANDUM

TO:

FROM: John D. Ludlow
Regional Economics and Water
Resource Management
Sea Grant Program

SUBJECT: Delphi Technical Panel 1

Thank you for agreeing to serve on the "Delphi" panel to consider technological developments that will have important influence on the water resources and related social and economic development of a region with the general physical and economic characteristics of the Grand Traverse Bay watershed area. This panel is made up of approximately 25 technical experts from the University of Michigan whose reputation and experience indicate that they can make a valuable contribution toward a definition of future technical environments for water resource management.

This Delphi exercise is part of a program to develop regional forecasts which emphasize the interdependence of economic and social development and water management decisions. A summary of the panel's judgments will provide background information for broader based Delphi panels--including regional planners and decision makers--which will consider the social and political as well as the technical environment.

Although a considerable amount of empirical data is being developed in the regional economics program and other Sea Grant projects, the best source of insight into the future is the judgment of well informed people. In the Sea Grant program, which employs the concepts of systems analysis and a multidisciplinary team of researchers, one of the most challenging issues is that of securing the consensus of those judgments on important issues. The Delphi techniques developed by researchers of the RAND Corporation provide a systematic method for obtaining and refining opinion and appear to have the flexibility to be effective in relating forecasting to regional planning.

The basic features of the Delphi method--anonymous response, numerical estimates, statistical group summaries, controlled feedback and reassessment--provide a systematic method for obtaining informed judgments that preserves the desirable characteristics of conventional methods of obtaining group judgments while minimizing some of the associated behavioral and administrative difficulties.

The panel is a multidisciplinary group and it is expected that some members will be experts in specialized areas while the competences and experiences of others will span a wide range of disciplines. Self appraisal indexes will permit the respondent to indicate his relative competence on specific issues and his familiarity with the region.

Experiments have shown that feedback and reassessment often result in the convergence of opinions as common elements of judgment are reinforced, ambiguities resolved, extreme positions clarified, and judgments formulated and refined as the interrelationships of events and the weighted opinions of experts in other areas are considered. However, the feedback and reassessment of informed judgments should be tremendously valuable even if it does not lead to convergence.

The information package for the first of four rounds of questioning is enclosed with this letter. In each round after the second a panel member will receive a copy of his past response and a summary of the values assigned by the entire panel and by various subgroups within the panel. Special instructions will accompany each information package but you may want to retain this letter for future reference. To insure anonymity each respondent will be identified by a number--which will be linked to his name only for the purposes of mailing out information packages and checking in the responses. This will be done by an adminsitrative assistant in the Sea Grant office. Some biographical information will be requested to help develop statistical summaries for subgroups within the panel. The first information package is relatively large because it contains much background information. An important feature of the Delphi method is that it does not require elaborate development and support of positions taken on each issue. After the panel has established which items are to be considered first,these will be continuously narrowed until only those items are left judged important to the exercise and on which a satisfactory consensus has not been reached.

The immediate objectives of the technical panel exercises are to use informed expert judgment to:

1. Establish the consensus on the relative importance of pollution sources for Grand Traverse Bay and their potential for abatement

2. Obtain the insight of technical experts into the marine resource problems and opportunities of the Grand Traverse Bay area

3. Generate a list of technological developments that would be important for the area

4. Determine the probability, timing, desirability, and feasibility of these developments

5. Establish a subpanel of experts knowledgeable in the technology of waste water treatment and disposal,and use their judgments to develop:

    a. Weighted alternative approaches to waste water treatment and disposal

    b. Research and informational references

    c. Research and informational needs

Please feel free to request any additional information--either by telephone (764-1366) or with your questionnaire response. A final summary and a complete analysis of the exercises will be sent to each respondent upon completion of the final round of information packages, expected to be round four.

APPENDIX B

GENERAL SUMMARY OF PROBLEMS AND OPPORTUNITIES IN MARINE RESOURCES AND ALTERNATIVES IN WASTE WATER COLLECTION, TREATMENT, AND DISPOSAL

The emphasis in the Delphi exercises will be on developing carefully formulated informed judgments. The panel will consider concurrently (1) interrelated regional development and marine resource problems and opportunities in the Grand Traverse Bay Watershed area, (2) the relative importance of sources of pollution and the economic and technical feasibility of controlling them, and (3) the technical environment relating to the treatment and disposal of wastewater.

The identification and evaluation of discretely defined problems and opportunities is a fundamental phase of a longer-term research program designed to provide knowledge, information, and methods for more comprehensive management of regional marine resources. The attached Exhibit 1 is a summary of general marine resource problems and opportunities for the Grand Traverse Bay Watershed area. The consideration of these issues involves a relatively high level of technical expertise and would benefit from an information exchange by technical experts prior to consideration by a broader panel.

The issue of wastewater treatment and disposal will be used to evaluate the effectiveness of the Delphi methodology in initiating the exchange of technical information and presenting the results in a form that can be used by regional planners and decision makers. In considering the issue, the objective is to gain the highest water quality

consistent with the maximum benefit to the people of the region.

General alternatives in waste collection, treatment, and disposal are presented in Exhibit 2. Exhibit 3 illustrates the effects of domestic and industrial wastewater on water-based activities.

Statement of the Problem [1/]

Domestic wastewater includes the liquid wastes originating in the sanitary conveniences of dwellings, business buildings, factories, and institutions. By comparison, industrial wastewater consists of the liquids discharged from commercial and industrial establishments including water used for processes, boiler feed, manufacturing, or cooling. Domestic wastewater is sometimes treated on an individual basis by means of septic tanks or cess pools and then discharged to the ground. Alternatively, domestic wastewater can be collected in sewers and transported to a central treatment plant; following treatment the wastewater (or effluent) is discharged to the ground or into a water course. When a central treatment facility is employed, the waste is typically referred to as "municipal wastewater" and usually consists of a combination of domestic and industrial waste.

1/ The statement of the wastewater treatment and disposal problem and the associated illustrations are adopted from a Sea Grant project document: F. A. Smith, et al., Fourteen Selected Marine Resource Problems of Long Island New York: Descriptive Evaluations, Report to the Marine Resources Council, Nassau-Suffolk Regional Planning Board, January, 1970 (Hartford, Conn.: The Travelers Research Corporation, 1970).

Domestic wastewater consists of complex organic matter which is subject to attack by micro-organisms that transform it to a stable form. Domestic wastes are heavily laden with disease-producing bacteria and viruses excreted by persons suffering from or "carrying" infectious diseases. When domestic waste is treated using septic tanks or cess pools, it is subsequently discharged to a ground water table, and, consequently, such wastes may eventually reach a surface water body. Since the transmission of wastes to surface water via the ground water table is circuitous, it is difficult to forecast quantitatively the ultimate effects on surface water quality.

In contrast, the impairment of surface water quality resulting from direct wastewater discharges is more evident. The impact of such a discharge depends on the characteristics of the waste stream before treatment, the type of treatment, and the location of the discharge. Available treatment methods can accomplish everything from the simple removal of large solid materials to the production of water of highest quality suitable for human consumption. Typically, however, treated municipal waste discharges affect the following surface water characteristics: pH, turbidity, suspended solids, bottom deposits, concentrations of bacteria and viruses, dissolved oxygen, phosphorous compounds, nitrogen compounds, and the concentration of oxygen-consuming organic matter. Industrial wastes (and municipal wastes with significant industrial waste compounds) may also influence a number of additional water quality characteristics, such as concentrations of metallic ions and other chemical

elements, depending on the composition of the industrial waste sources. Changes in these water quality characteristics in turn can significantly affect the types and quantities of biological organisms inhabiting the affected environment.

Changes in the levels of environmental characteristics noted above can influence a large number of water-related activities which, in the case of Grand Traverse Bay, include swimming, boating, water-skiing, and commercial and sport fishing. The specific groups of people affected quite naturally include all those associated with these activities as direct participants, and may even affect many individuals who do not make direct use of the Bay insofar as they feel "less good" when the environment is degraded.

The substantive contribution of the Delphi exercises is expected to be planning-oriented information concerning an issue that is extremely important to regional decision makers together with the identification of informational needs and the development of priorities for additional research in the Sea Grant program.

MARINE RESOURCE PROBLEMS AND OPPORTUNITIES FOR THE GRAND TRAVERSE BAY AREA

Sport and Commercial Fishing

Waste from Marine Vessels
- a. oil and gas pollution
- b. sanitary wastewater discharges
- c. overboard trash disposal

Water Recreation
- a. quality
- b. quantity
- c. ancillary facilities
- d. conflict between residents and non-residents
- e. seasonal and daily variations in demand
- f. conflict between recreational and non-recreational uses
- g. conflict among different recreational uses (e.g., water skiing vs. swimming and fishing)

Solid Waste Disposal
- a. households
- b. industrial
- c. commercial
- d. government units

Thermal Pollution and Thermal Enrichment

Oil Spill Pollution

Chemical Pesticides
- a. households
- b. agriculture

Fertilizers
- a. households
- b. agriculture

Domestic and Industrial Wastewater Treatment and Disposal

Exhibit 1. Marine resource problems and opportunities.

ALTERNATIVES IN WASTE COLLECTION AND TREATMENT

1. REGIONAL VS. LOCAL COLLECTION AND TREATMENT

2. MUNCIPAL-INDUSTRIAL

   Spectrum of combined collection/treatment possibilities

3. SEPARATE VS. COMBINED SEWERAGE SYSTEMS (I.E., SEPARATE SANITARY AND STORM SEWERS)

4. TREATMENT ALTERNATIVES

   a. Primary

   b. Secondary (conventional)

      (1) activated sludge

      (2) trickling filter

      (3) lagoons

   c. Secondary (with phosphate removal)

   d. Secondary (physicochemical--high level treatment)

   e. Tertiary (for use with secondary but not needed if you have physicochemical)

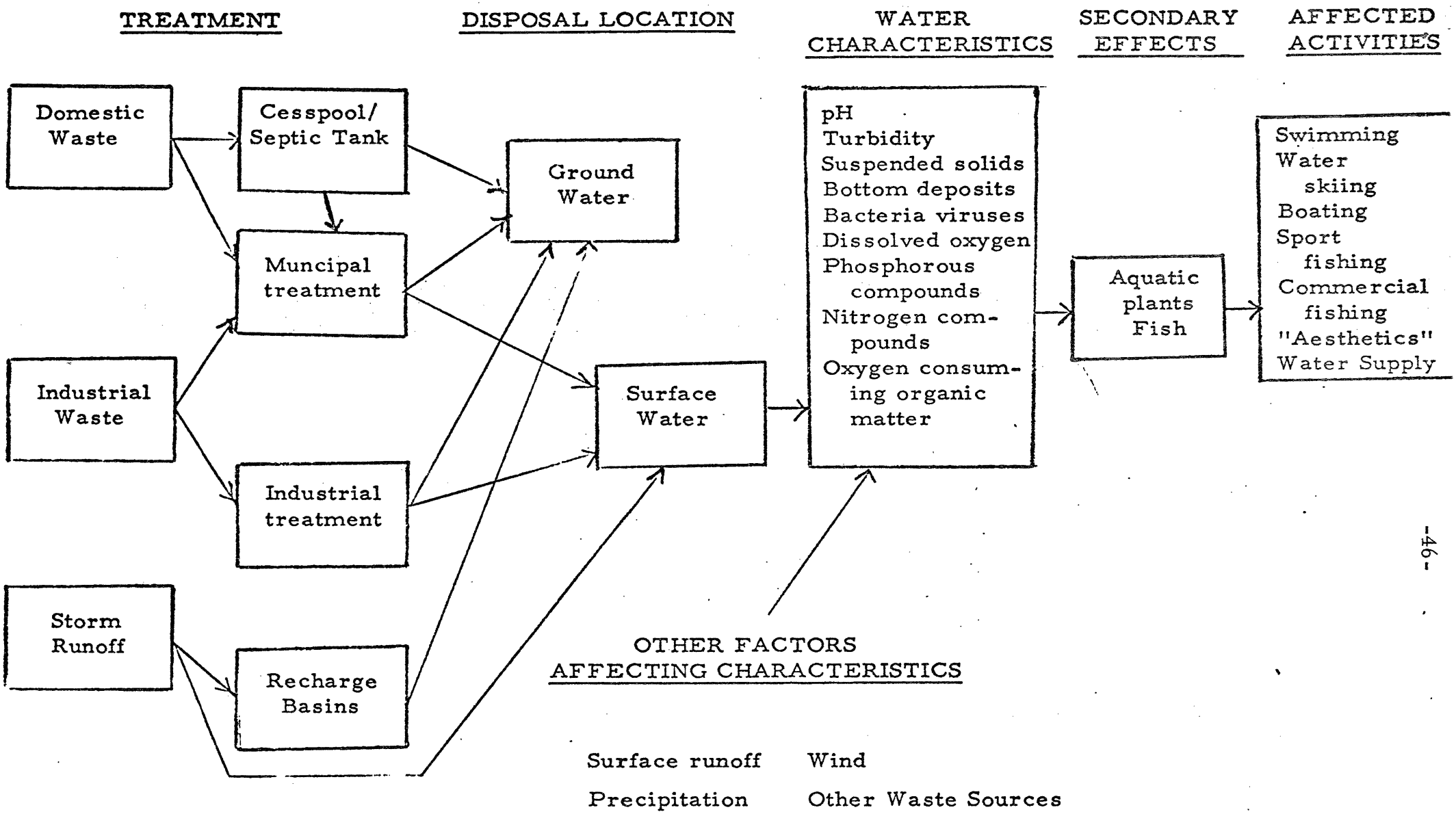
DISPOSAL

   a. Spray irrigation

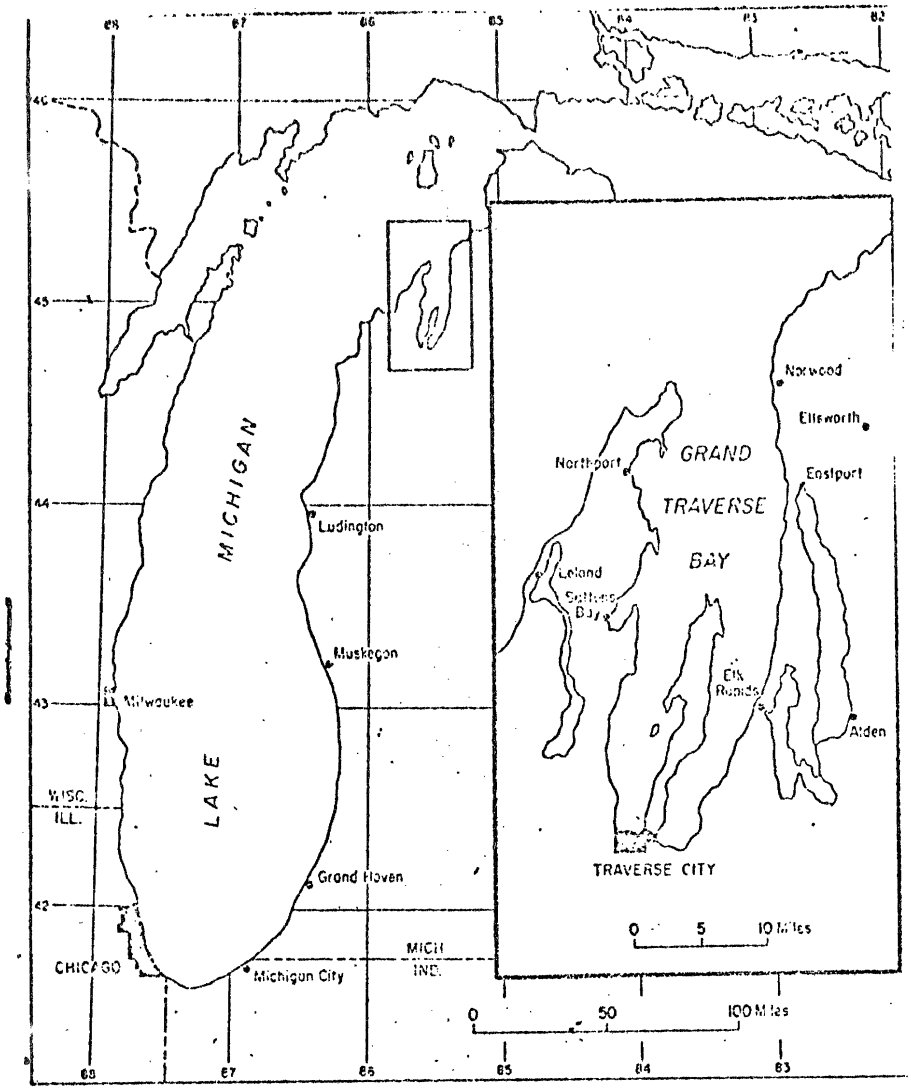
   b. Industrial or municipal reuse

   c. Discharge to receiving water

Exhibit 2. Alternatives in waste collection, treatment, and disposal.


TREATMENT
DISPOSAL LOCATION
WATER CHARACTERISTICS
SECONDARY EFFECTS
AFFECTED ACTIVITIES
Domestic Waste
Cesspool/ Septic Tank
Muncipal treatment
Industrial Waste
Industrial treatment
Storm Runoff
Recharge Basins
Ground Water
Surface Water
pH
Turbidity
Suspended solids
Bottom deposits
Bacteria viruses
Dissolved oxygen
Phosphorous compounds
Nitrogen compounds
Oxygen consuming organic matter
Aquatic plants Fish
Swimming
Water skiing
Boating
Sport fishing
Commercial fishing
"Aesthetics"
Water Supply
OTHER FACTORS AFFECTING CHARACTERISTICS
Surface runoff
Precipitation
Wind
Other Waste Sources

LEFT. The Grand Traverse Bay (see inset) serves as a model for the University of Michigan's Sea Grant Pilot Program. It provides a microcosm of the problems and possibilities encountered in Lake Michigan and the Great Lakes region.



RIGHT. The ten counties making up the Northwest Michigan Development District approximate the Grand Traverse Bay Watershed area. It is representative of many areas in the Great Lakes region where economic development and quality of life are closely related to water resources. The numbers in parentheses are preliminary 1970 census population figures.

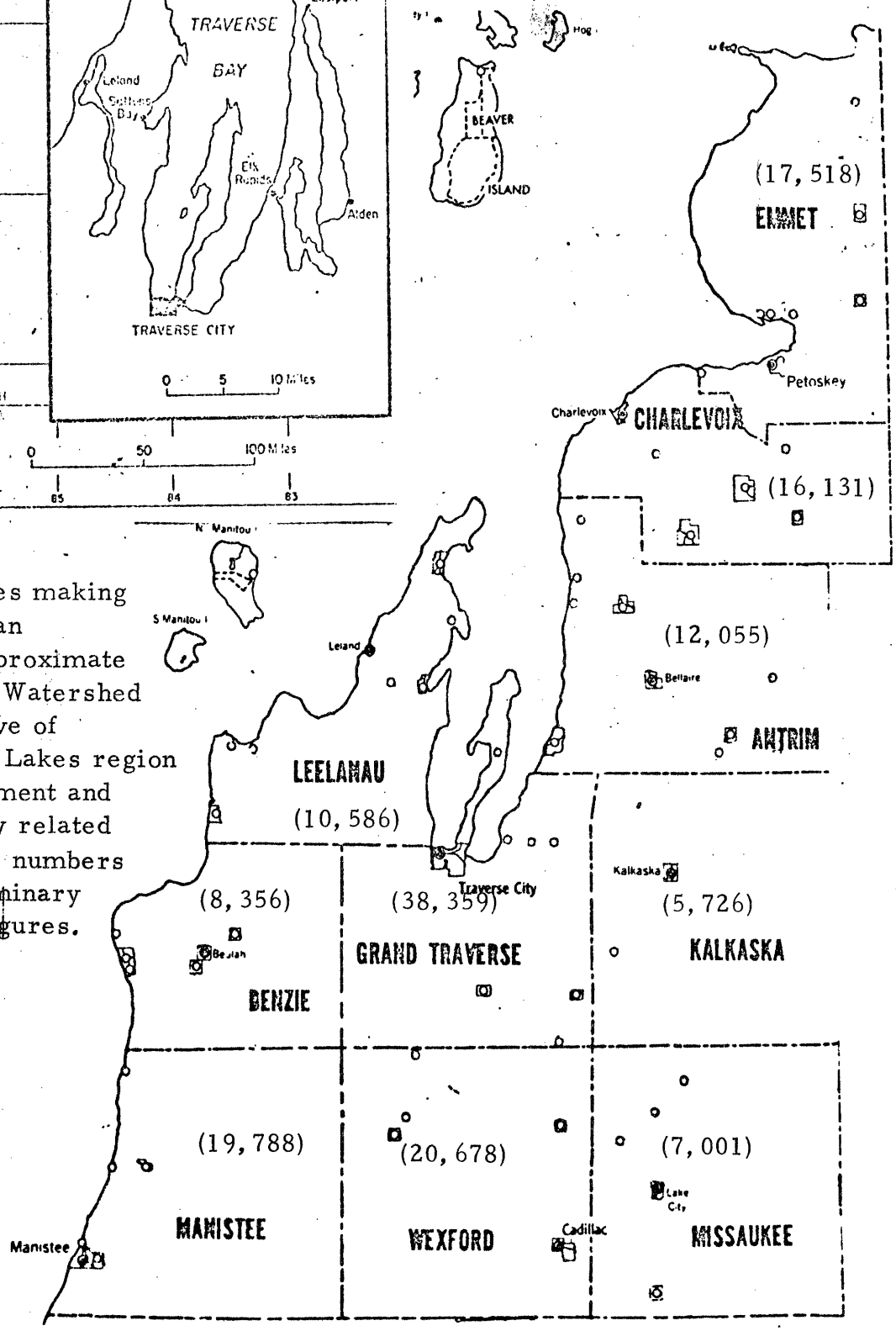


Exhibit 4. The Grand Traverse Bay Region

APPENDIX C

SOCIOECONOMIC DEVELOPMENT IN THE GRAND TRAVERSE BAY REGION

The Northwest Economic Development District is a state planning region made up of ten counties and approximates the Grand Traverse Bay watershed area. (See Exhibit 4.)

The major natural assets of the region are related to its water resources. It has hundreds of miles of Lake Michigan shoreline and numerous clear water inland lakes and streams. It has thousands of acres of pine and hardwood forest abundant in wildlife, areas of clean fine sand, and deposits of gravel, limestone, and salt. The whole district is characterized by glaciated land with high rolling hills, broad valleys, and plateaus. It centers on the 45th parallel and has a seasonal climate with warm pleasant summers and cold snowy winters.[1/]

It is part of the Upper Great Lakes Region. This is an area of 119 counties in the northern parts of Michigan, Minnesota, and Wisconsin that has been identified as socially and economically disadvantaged, and has been the

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[1/] "Prologue for Accelerated Growth of Economy," a report of the Northwest Michigan Development District, Traverse City, Michigan, Oct., 1968.

subject of intense study and special funding by the federal government in an effort to reestablish social and economic development at a rate comparable to the rest of the country.

The weaknesses in the economy of the Upper Great Lakes Region include

- Small population
- Slow population growth
- High outmigration
- Slow structural change in industrial employment
- High unemployment
- Low per capita income
- Large low-income class
- Small high-income class[2/]

The Upper Great Lakes Region is characterized as a rural area without much potential for agricultural production. It has lagged behind the nation and the remaining parts of Michigan, Minnesota, and Wisconsin in economic development. Manifestations of this lag are the income gap, the steady outmigration, and the persistently high levels of unemployment. The region has seemed inaccessible and unproductive to business and the environment hostile to it.[3/] The Grand

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[2/] Battelle Memorial Institute, "Industries Suited for the Upper Great Lakes Region," a report by David C. Sweet, John M. Griffin, and Hal S. Maggied, Columbus, Ohio, 1970.

[3/] Ibid., and "Development Strategies—Upper Great Lakes Region," Annual Report of the Upper Great Lakes Regional Commission, Washington, D. C., Jan., 1969.

Traverse Bay area, a subregion in the Upper Great Lakes Region, has a socioeconomic development history that approximately parallels that of the larger region. However, in the past ten years there have been some significant changes in the trends of the social and economic development of this region and it may be helpful, as a frame of reference, to compare the development of the Grand Traverse Bay area with the whole Upper Great Lakes Region, as well as with the state of Michigan and the nation.

The economic history of the region shows that its natural resources have been exploited and depleted in turn by fur traders, loggers, and various forms of agriculture. Subsequent experimentation and management have enabled wood products and agriculture to regain a significant but not leading role in the area's present economic structure.

The area has long been a favorite summering place and with the development of winter recreational facilities—skiing and snowmobiling are the two of the fastest growing forms of recreation in the United States—and the introduction of coho and king salmon for sport fishing, it has strengthened its claim to be the most popular tourist area in Michigan, which in 1967 ranked as the fourth most popular vacation state in the nation. It now serves as a vacation land for people in the metropolitan areas to the south, and tourism and recreation, together with supporting services, constitutes the leading economic activity of the region.

The region's highest population level, 164,000, was reached in 1910. With the depletion of the forests and the cessation of related jobs the population dropped sharply. By 1920 it was only 132,000, and it reached a low of 120,000 in 1930. Preliminary 1970 census figures reveal that approximately 155,000 people now live in the region—a density of less than 35 per square mile. The population growth during the 1950-60 period was 2.6 per cent, far lower than that of the state (24 per cent) or the nation (18.5 per cent). However, in the 1960-70 period the gap narrowed as the region's growth increased to 11.4 per cent for the decade, while the growth of the state and the nation eased to approximately 13 per cent. Since the region's growth rate increased steadily throughout the period it is not unreasonable to assume that its annual growth rate at the present time exceeds that of the state and nation.

However, growth and population density are not uniform throughout the region. Grand Traverse County currently has approximately 25 per cent of the region's population. Its population increased by 14.5 per cent between 1960 and 1970. The Traverse City metropolitan area has a base population of 32,000 and has been designated the primary growth center for the region in predictions based on the variety and quality of the business and industry already established there.[4/] Its geographical location with access to Grand Traverse Bay, and the size of its tourist, commercial, and manufacturing

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[4/] "Prologue for Accelerated Growth of Economy."

activities make it an excellent focal point from which growth can be generated to radiate throughout much of the region and be reinforced by the secondary growth centers of Manistee, Cadillac, and Petoskey. These secondary centers of growth have populations ranging from 6,000 to 11,000, are strategially located, and their social and economic development show trends similar to that of Traverse City.

During the summer months, with the influx of vacationers, the population of the area approximately doubles. These summer people require services and their property comprises a substantial portion of the local tax base. Many of the natural resource development projects must have the support of these people to be effective.

Immediately to the south of the region are some of the fastest growing areas in the United States and there are some indications that the population growth of the region will increase as expansion gradually spreads north.

One important indicator of possible future population growth is the net migration of people in and out of the area. The prime motivating force of migration is economic in nature, with quality of life gaining importance as a secondary motive. Between 1950 and 1960 the region experienced a negative migration rate of 9.3 per cent, compared to a net positive rate of 2.5 per cent for the state. However, the migration rate of the area in the past ten years has gradually reached the neutral position which it holds at present. Some of the reduction in net outmigration is due to the movement into the area of people of retirement age. A negative migration rate

has an adverse effect on a region since the people most likely to move out are the young, relatively well-educated and productive workers who have the widest range of job opportunities open to them. The negative migration rates of the past are reflected by an imbalance in age distribution; the proportion of the region's people in the older age group is higher than that of the state or nation and the proportion in the most productive age bracket correspondingly lower. The youngest and oldest age groups make the greatest demands on a community for social and welfare services such as education, recreation, and medical care and are least able to contribute to meeting the cost of these programs. The financial burden falls on the age group most adversely affected by outmigration.

Indians make up the region's only significant minority group and represent less than 2 per cent of the population.

Among the various measures for determining the relative importance of any particular industry to the economy of a region, the level of employment is particularly meaningful to this area. In 1968 all of the ten counties in the region were qualified for special grants, loans, and technical assistance under the Economic Development Act on the basis of high rates of unemployment.[5/]

Historically, the region has had a narrow-based economy, resulting in economic instability when the resource supporting the economy was depleted. Substantial growth and diversification

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5/ Ibid.

have taken place in recent years and the region's economy has become less reliant on seasonal and low-wage industries.

In 1967 the five economic sectors employing over 10 per cent of the region's work force represented 84 per cent of the region's employment. These were manufacturing 27 per cent, wholesale and retail trade 16 per cent, self-employed 15 per cent, government 14 per cent, and services 12.5 per cent (Table 1). When compared to 1960, the most significant gains were in services, government, and manufacturing.

Agriculture employed a stable 7.5 per cent of the work force but represents a more important portion of the economy than employment figures indicate because it is resource based and has a high proportion of value added in the final product that is sold. In addition, approximately 45 per cent of the product produced is over and above the needs of the people in the region and is exported. These experts bring money into the region or are used to import other products.

The manufacturing sector offers the greatest opportunity for economic growth in the region but also the greatest threat to environmental quality and the dependent tourism and recreational activity. Manufacturing was the largest employer in 1960 and 1967 with a relatively strong growth rate during that period. The ratio of employment in manufacturing for the region is below that of the state, but above that of the Upper Great Lakes Region. Available regional employment data

TABLE 1

Comparison of Employment by Major Industry, 1967

	United States	Upper Great Lakes	Michigan	* G.T.B. Region
Agriculture, Forestry, Fishing	4.7	13.2	2.8	7.5
Mining	.8	2.5	.4	...
Construction	4.0	2.8	4.9	3.8
Manufacturing	26.5	20.0	36.8	26.8
Transportation and Utilities	5.8	5.0	4.4	3.5
Wholesale and Retail Trade	18.4	16.2	18.5	15.5
Finance, Real Estate, Insurance	4.4	2.3	3.5	2.0
Services	13.5	9.8	11.5	12.5
Government	15.9	15.3	13.2	13.9
Unclassified	6.0	12.9	4.0	14.5
TOTAL	100.0	100.0	100.0	100.0

Sources: Battelle Memorial Institute, "Industries Suited for the Upper Great Lakes Region," a report by David C. Sweet, John M. Griffin, and Hal S. Maggied, Columbus, Ohio, 1970.

*Michigan Employment Security Commission, Bureau of Business Research Calculations.

for 2-digit SIC manufacturing industries accounts for over 85 per cent of manufacturing employment used to develop the ratios by economic sectors. These data show important changes in the industrial structure of the region. In the 1959-67 time period total manufacturing employment gained 43 per cent, from 9,307 to 13,278. Grand Traverse County accounts for approximately 25 per cent of the region's employment in manufacturing and experienced a growth rate of 45 per cent in this area over the same time period. Those industries within the region, which deviated significantly from the average growth rate, are shown in Table 2.

In some industries it is necessary to go to the 3-digit SIC code to gain an accurate impression of changing demand or technology. For example an impressive gain from 387 to 889 (130 per cent) in motor vehicles and equipment (SIC-371) was overwhelmed by a sharp drop in ship and boat building and repairing (SIC-373) resulting in the apparent poor growth performance in transportation equipment (SIC-37).

The Upper Great Lakes Region historically has relied on natural-resource based industries. If paper and allied products are included in the category of industries dependent on natural resources, the total employment in this area was 55 per cent in 1960 and 51 per cent in 1967 of total manufacturing employment. Natural-resource based industries are not expanding as rapidly nationally as some of the fabricating and specialty industries.[6/]

[6/] Battelle Memorial Institute, "Industries Suited for the Upper Great Lakes Region."

TABLE 2

Employment in Largest Manufacturing Industries in the Region

SIC Code	Industry	Employment 1959	Employment 1967	Employment Change Number	Employment Change Per Cent
	Employment in Faster Growth Industries				
36	Electrical equipment and supplies	314	1,576	1,262	402
27	Printing and publishing	276	528	302	137
35	Machinery except electrical	699	1,614	915	131
30	Rubber and plastics	247	519	272	110
33	Primary metals industry	544	1,101	557	102
	Employment in Slower Growth Industries				
28	Chemical and allied products	462	421	-41	-9
32	Stone, clay and glass products	497	467	-30	-6
37	Transportation equipment	1,391	1,498	37	3
23	Apparel and other textile products	840	877	37	4
26	Paper and allied products	621	643	22	4
24	Lumber and wood products	542	580	38	7
	Employment in Average Growth Industries				
20	Food and kindred products	1,452	1,716	264	19
34	Fabricated metal products	848	1,079	231	27
25	Furniture and fixtures	370	433	113	35
	Total Manufacturing Employment*	9,307	13,278	3,971	43

*Not the sum of individual columns since smaller industries in the region are included in the total but not in the categories.

Source: Bureau of Business Research, University of Michigan.

By comparison, this group of industries is much less important in the Grand Traverse Bay Region, where it constituted 32.5 per cent of total manufacturing employment in 1960 and 25.6 per cent in 1967. (See Table 3.) Agriculture (7.5 compared to 13.2 per cent) and mining (negligible compared to 2.5 percent) are other resource based segments which are less important in the Grand Traverse Bay area from the standpoint of employment than in the Upper Great Lakes Region.

Table 4 indicates that the industries in which employment opportunities in the region are increasing most rapidly are generally those in which the wages are relatively higher.

Table 5 shows that per capita income for the region was approximately half that of the national average in 1940, but that the income trend as a per cent of United States average per capita income has subsequently steadily improved relative to the nation, the Upper Great Lakes Region, and state of Michigan.

Supporting factors for industrial development include transportation, recreation, environmental quality, communications, energy-generating utilities, water and sewer facilities, housing quality, investment capital, and institutional resources. Only a brief word about the most apparent problems and opportunities in these areas will be offered.

Transportation includes both the facilities and processes involved in distribution of a product and acquisition of the factors involved in production. Except for natural resource based industries the regional manufacturers are at

TABLE 3

Employment in Natural-Resource-Oriented Industries,
Grand Traverse Bay Region 1959-60

Industry	Employment		Percent of Total	
	1959	1967	1959	1967
Food and Kindred Products	1,452	1,716	15.7	12.9
Lumber and Wood Products	542	580	15.8	4.4
Stone, Clay, and Glass	497	467	5.3	3.5
Paper and Allied Products	621	643	6.7	4.8
Total Natural-Resource-Oriented Industries	3,112	3,406	32.5	25.6
All Manufacturing Industries	9,307	13,278	100.0	100.0

Source: Table 2.

TABLE 4

Average Earnings Per Full-Time Employee

Michigan Upper Great Lakes Region

Industry	1962 Average Wage	1962 Per Cent Ind. Average	1962 Per Cent U.S. Average	1967 Average Wage	1967 Per Cent Ind. Average	1967 Per Cent U.S. Average
Agriculture	$1,544	88	30	$2,902	117	46
Mining	7,012	116	137	8,346	110	133
Con. Const.	4,708	80	92	7,613	102	121
Manufacturing						
Food and Kindred Products	4,433	85	86	5,492	87	87
Textiles	0	0	0	0	0	0
Apparel	2,719	76	53	4,694	110	74
Lumber and Wood Products	4,672	114	91	4,169	80	66
Furniture	3,769	81	73	4,334	79	69
Paper	6,358	106	124	7,819	109	124
Printing*	7,310	123	142	6,364	90	101
Chemicals	6,888	100	134	7,130	87	113
Petroleum	4,500	60	87	7,541	84	120
Rubber*	4,735	82	92	5,603	84	89
Leather	3,949	104	77	4,678	101	74
Stone and Clay	6,112	107	119	7,004	103	111
Primary Metals*	5,517	80	107	6,888	86	109
Fabricated Metals	5,051	80	98	6,012	80	95
Machinery*	5,704	87	111	6,868	87	109
Electrical Machinery*	3,824	62	74	4,182	59	66
Transportation Equipment	4,864	68	95	0	0	0
Instruments and Miscellaneous	4,150	75	81	5,005	75	79
Transportation						
Transportation Services	6,890	101	134	8,300	102	132
Utilities	6,598	107	128	8,735	117	139

Table 4 (Continued)

Industry	1962 Average Wage	1962 Per Cent Ind. Average	1962 Per Cent U.S. Average	1967 Average Wage	1967 Per Cent Ind. Average	1967 Per Cent U.S. Average
Finance, Real Estate, Insurance	$4,758	87	93	5,791	86	92
Services						
Hotels	2,898	85	56	$3,583	88	57
Personal Services	2,028	70	39	2,060	56	32
Business Services	4,955	90	96	5,233	81	83
Amusement Services	3,438	73	67	4,219	73	67
Professional Services	2,387	64	46	2,690	57	42
Government						
Federal Civilian	7,318	121	143	7,893	105	125
State and Local	4,296	85	84	5,417	88	86
TOTAL	$4,400	86	86	$5,419	86	86

*Faster growing industries in the Grand Traverse Bay Region.

TABLE 5

Per Capita Personal Income

	1929	1940	1950	1959	1962	1965	1967
Region	366	313	993	1,466	1,627	2,079	2,378
Michigan	806	683	1,714	2,264	2,449	3,054	3,395
Upper Great Lakes	432	382	1,090	1,608	1,779	2,076	2,419
United States	705	592	1,496	2,161	2,368	2,760	3,159

Per Capita Relatives
(Per Cent of National Average)

Region	52	53	66	68	69	75	75
Michigan	114	115	113	105	103	110	107
Upper Great Lakes	62	65	73	75	75	75	77

Source: "Industries Suited for the Upper Great Lakes Region."

a disadvantage in competing with firms located closer to the major markets—disadvantages which may be offset by advantages in other factors such as cost and availability of labor. However, products with some combination of high value to unit weight, short transit time, and special service requirements are amenable to air transportation, in which case locational advantages are related to airport accessibility. In such cases, the integrated industrial park-airport concept at Traverse City gives an area which is otherwise relatively poorly located from the standpoint of transportation definite advantages for distribution of products and acquisition of the materials for production. Another important advantage is the convenience of workers and management to fly to and from business engagements and social, cultural, and recreational centers which is an inducement in recruiting personnel.

Prospective industries and businesses are concerned not only with plant location advantages but also are placing an increased emphasis on community services and the quality of living conditions.

The environmental quality of the region and its recreational opportunities not only provide the basis for the leading economic activity—tourism and recreation—but also aid in attracting other businesses and industries. The region faces some critical decisions in determining the trade-offs between economic development and environmental quality.

One of the more insidious problems of the region is a deficiency of adequate housing. In some communities the shortage is severe enough to prevent workmen from moving into the area and to restrict business expansion. The 1960 census report indicated that only 25 per cent of the housing units were connected to public sewers and only 76 per cent had hot and cold running water. The 1970 figures have not been analyzed as yet but the difficulties in obtaining home loans throughout the nation in recent years together with the lack of individual security to gain loans, the limited resources, and the conservative lending practices of financial institutions within the region make it unlikely that the situation has improved dramatically.

Hospital facilities are generally adequate, and at Traverse City and Petoskey the medical complexes are exceptional, both in quality and diversity of their staff and equipment.[7/]

The lack of venture capital from financial institutions within the region is a restricting factor. Many potentially successful operations are never started and those that are financed and operated by "outsiders" are often treated with skepticism by the local people.

Because educational institutions provide much of the training needed to create a productive labor force and are a factor in attracting desirable industries and services the

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7/ "Prologue for Accelerated Growth of Economy."

quality of its education is vital to the development of an area. In general, schools in the Grand Traverse Bay Area are well cared for and adequately staffed. Beyond the high school level there is Northwestern Michigan College at Traverse City and North Central Michigan College at Petoskey, both basically two-year vocational-technical schools. Northwestern Michigan College has recently established a Great Lakes Maritime Academy with a three-year program to train seamen specifically for Great Lakes shipping.

Perhaps the most critical issue facing the communities in the region is that of waste water treatment and disposal. Only half of the communities provide a sewer system. The use of inadequate septic tanks and outdoor privies in close proximity to lakes and streams present an added hazard to the environment when the population is more than doubled during the warm summer months. The present sewage system at Traverse City has a primary treatment plant able to pass peak flows of only 13 MGD (million gallons per day). Plant efficiencies are less than 20 per cent removal of suspended solids.

During 1969 the state of Michigan's Water Resource Commission rated 64 industrial establishments in the area, of which 31 had less than adequate waste water controls. One of these was the Morgan-McCool cherry and apple canning plant which was reportedly dumping into the bay 547,000 gallons of waste every day during the canning season in July and August.[8/]

[8/] "Traverse City's 'Shaggy' Waters Endanger Tourism," Chicago Tribune, Oct. 26, 1970.

New Opportunities

Important technological and sociological changes are providing new opportunities for rural areas with limited agricultural potential in the Upper Great Lakes Region. Industries and workers are recognizing increasing diseconomies associated with urban locations. Many highly skilled people are giving added importance to the quality of the environment when making vocational and locational decisions. Interstate highway systems, better employment information systems, and a more mobile labor force make it easier for industries to locate away from urban areas. In an increasingly mobile and affluent society people are willing to travel greater distances for both work and recreational purposes.

With imaginative planning and preparation, the Grand Traverse Bay Region can benefit socially and economically from these trends. Many of the region's characteristics that were once considered sources of weaknesses, such as low population density and remoteness from metropolitan areas, could become assets. If the younger segments of the population can be properly educated and trained and can be induced to remain in the region as the nucleous of a productive labor force, and if ways can be found to utilize the experience and talents of the older segments, the problems associated with present imbalances in the age structure of the region may become opportunities.

There is considerable evidence of pollution and deterioration in the water resources of the region. However, the people of Traverse City, in cooperation with five surrounding townships, have assumed the leadership in seeking solutions to the area's water pollution problems by initiating the development of a regional sewage treatment plan. The present sewage treatment plant will be expanded to meet flow capacities predicted for the year 1990 and will be modified to provide secondary treatment capable of removing 90 per cent of the impurities from sewage and industrial wastes, including 85 per cent phosphate removal. Once the plant is built, industries will be required to divert their wastes into the municiple treatment system or to treat it themselves to meet pollution control standards.

Since 1967, the Economic Development Assistance Program has provided funds for, among other projects, the expansion of Antrim County and Traverse City Airports, water and sewer facilities in the village of Kalkaska, marinas in the cities of Petroskey, Manistee, and Northport, and dock facilities for the Great Lakes Maritime Academy at Northwestern Michigan College.

There are many indications that the people in the region are acting to enhance the positive aspects of the region. Hunting, skiing, and snowmobiling are being added to tourist and recreational areas to complement their summertime attractions and provide a year-round business. There appears to be widespread public support of the excellent health care

facilities at Petoskey and Traverse City and the money brought into the region by outsiders who use these facilities could provide an important source of strength for social and economic development throughout the region.

Short-field landing and takeoff capability in general and commercial aircraft could ease the problems associated with inadequate access roads to recreational areas. Mobile and manufactured homes could be a partial solution to the shortage of adequate housing in the region.

Summary

This region has approximately 155,000 residents and is Michigan's most popular area for recreation and tourism. However, in recent years it has been considered by the federal government as part of a socially and economically depressed area.

Early in this century the region was characterized by vigorous economic activity and growth which, however, suffered a sharp decline shortly after 1910. Only recently has the region recovered a population and industrial growth comparable to the rest of the state and the nation.

The following have been major causes of the economic decline of the region:

- The displacement of labor in resource based industries because of technological change
- The deterioration of resources—fur, lumber, and agriculture—and increased competition

from other areas that supply the same resources

- The small size of the region's enterprises
- Remoteness from metropolitan markets

As a direct result of the economic decline, there has been a migration from the region of people in the most productive age group and of those with the most marketable skills. This has created an imbalance in the age and skill levels of the population. Chronically high unemployment rates have been experienced due to the lack of match between job opportunities and the characteristics of the labor force, the scarcity of job opportunies, and reliance on seasonal economic activities.

The long period of lagging economic opportunity and growth and the low density of population has tended to separate the region from the mainstream of national, social, and economic development. This has had a cumulative effect on the supporting activities needed to sustain economic growth and has been reflected in such things as inadequate housing, lack of investment funds, outdated waste water treatment and disposal systems.

In recent years there have been encouraging signs of favorable trends in some of the key factors used in measuring the region's economic and social health and its potential for development. Based upon the region's strong growth in employment between 1959 and 1967 and a shift to faster growing industries, it is likely that employment growth rates will exceed that of the Upper Great Lakes Region and the United States in the next decade.

There are also some important new technical and social forces that will tend to make the Grand Traverse Bay Region increasingly attractive for new businesses, industries, homes, and recreational activity. At the same time there is encouraging evidence that the people of the area are actively concerned not only with the economic and social development of their region but also with the management of the water resources and environmental qualities which are the region's main source of economic potential. They are fortunate to live in a region where flexibility is still possible in making the critical decisions concerning the trade-offs between economic development and environmental quality.

APPENDIX D

PARTICIPATION LETTER

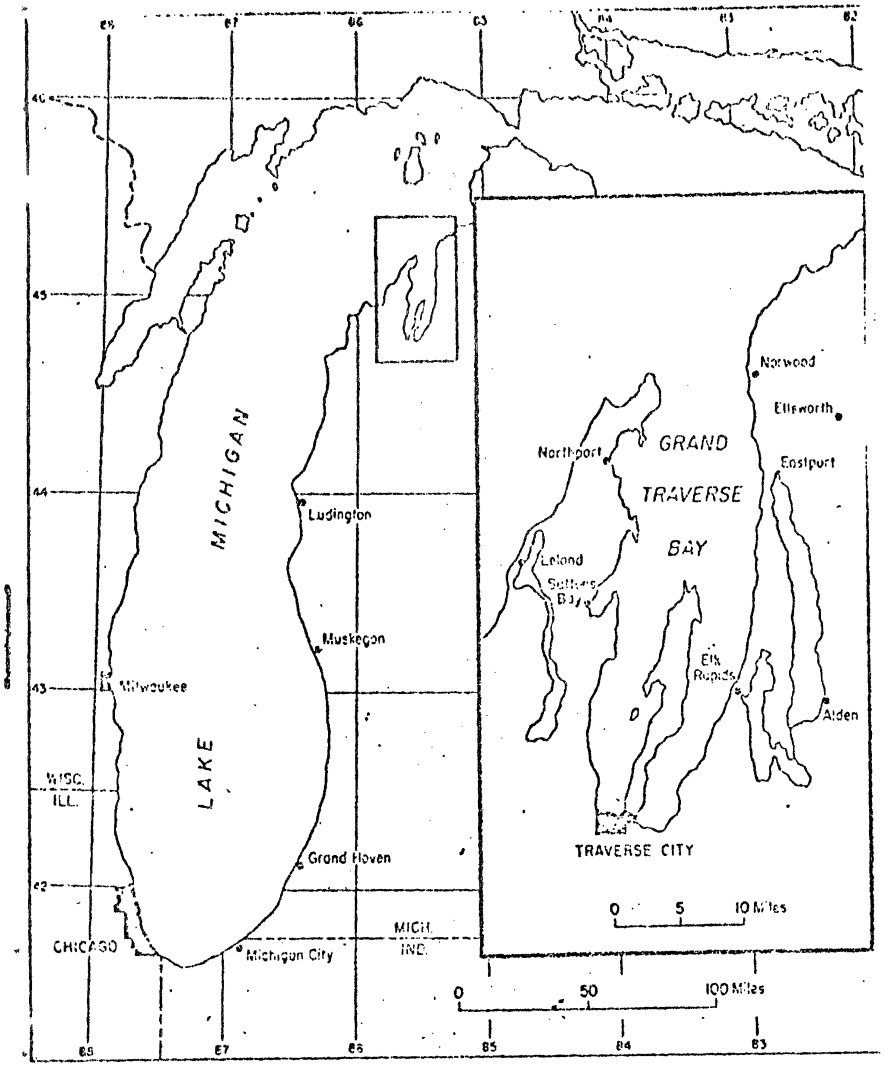
Dear (Regional Influential):

You are invited to participate in an exchange of information with the researchers in the Sea Grant Program of the University of Michigan. From this exchange, forecasts of the impact of technological and social changes on the Grand Traverse Bay area (see the attached Exhibit 5 for a more precise definition of the area) will be developed.

The aims of the Sea Grant Program of the University of Michigan are: (1) to establish standards of expertise and a center of knowledge for Great Lakes research, and (2) to provide useful information as a service to regional planners and decision makers. The Grand Traverse Bay area was selected because it is representative of many areas in the Great Lakes region where economic development and the quality of life are closely related to water resources.

Although a considerable amount of empirical and scientific data is being gathered and used as a basis for projections, the judgments of informed people form the best source of insight into the future. To obtain informed judgments systematically, the Sea Grant Program will use the Delphi techniques developed by the researchers of the Rand Corporation as part of their study of methods for improving decision making. The method is designed to obtain the most reliable consensus of opinion from anonymous responses by a group of experts to a carefully designed program of sequential interrogations.

The exchange of information is accomplished through a series of information packages referred to as rounds. The early rounds are controlled brainstorming sessions in which the respondent is encouraged to present what he feels will be important technical and social developments in the future. The responses are edited to eliminate duplication or ambiguous items, and are then combined and fed back to the group. In subsequent rounds the respondents will be asked to attach numerical estimates to each development indicating its probability, timing, importance and impact on the Grand Traverse Bay area. Self-appraisal indexes will permit the respondent to indicate his relative competence on specific issues and his familiarity with the region.



LEFT. The Grand Traverse Bay (see inset) serves as a model for the University of Michigan's Sea Grant Pilot Program. It provides a microcosm of the problems and possibilities encountered in Lake Michigan and the Great Lakes region.

RIGHT. The ten counties making up the Northwest Michigan Development District approximate the Grand Traverse Bay Watershed area. It is representative of many areas in the Great Lakes region where economic development and quality of life are closely related to water resources.

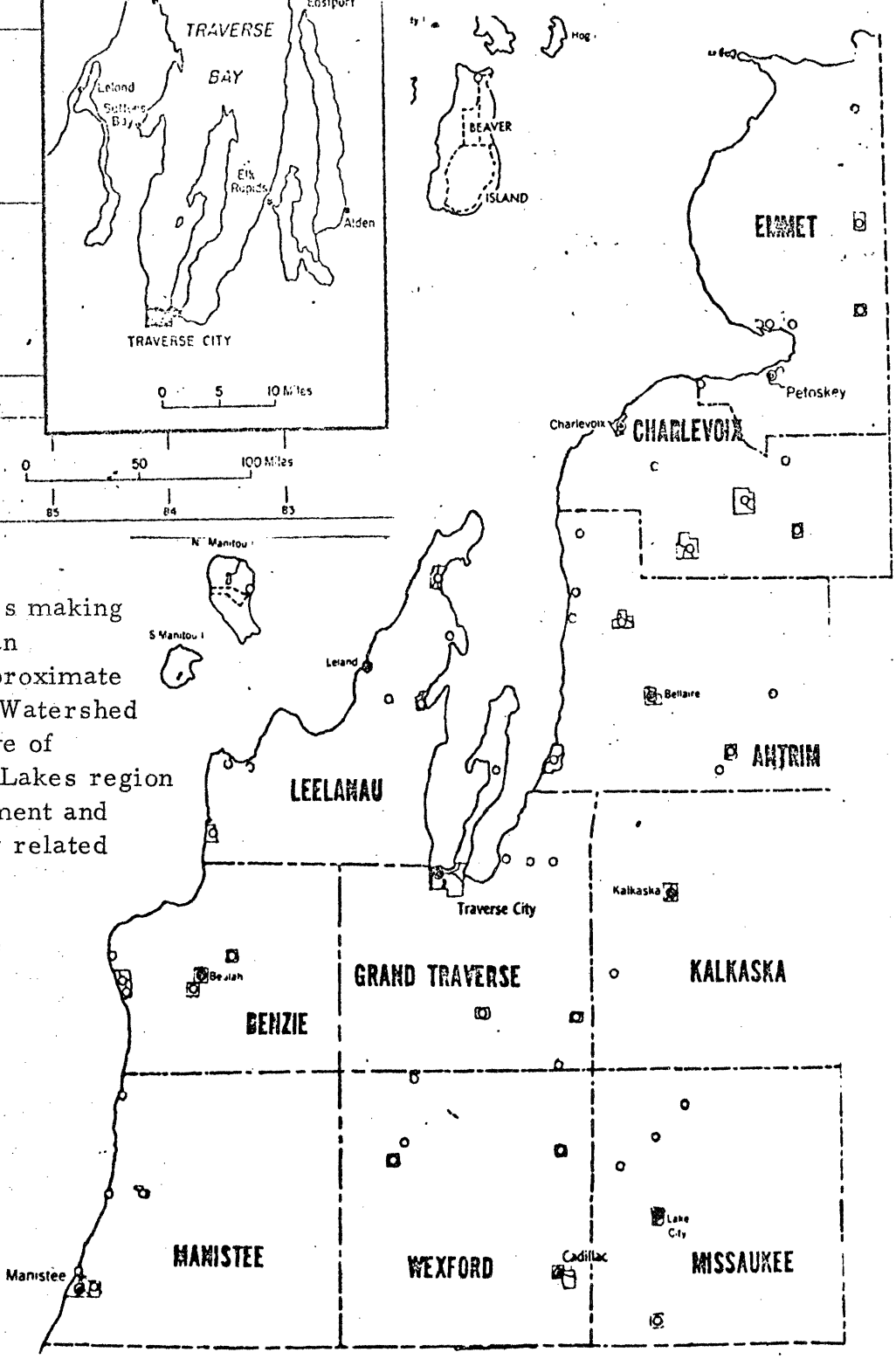


Exhibit 5. The Grand Traverse Bay Region

After the second round, each participant will receive a copy of his past response with a statistical summary of the values assigned by the entire panel and by various subgroups within the panel. Information obtained from research in the Sea Grant Program and from a Delphi panel of technical experts will also be provided as background information to assist the participants in the formulation of their individual judgments.

Experiments have shown that feedback and reassessment often result in the convergence of opinions as common elements of judgments are reinforced, ambiguities resolved, extreme positions clarified, and the judgments formulated and refined as the interrelationships of events and the weighted opinions of experts in other areas are considered. However, the feedback and reassessment of informed judgments should be tremendously valuable even if they do not lead to convergence.

An important feature of the Delphi method is that it does not require elaborate development and support of positions taken on each issue. After the panel has established which items are to be considered these will be continuously narrowed until only those items are left which have been judged important to the exercise and on which a satisfactory consensus has not been reached.

In assessing the likelihood of social developments, quantitative probability estimates give an exaggerated impression of precision. You are requested to complete the form on probability assessments so that an ordered list of verbal phases that intuitively express the notion of numerical probability can be developed for your panel.

To insure anonymity each respondent will be identified by a number—which will be linked to his name only for the purposes of mailing out information packages and checking in the responses.

Please feel free to request any additional information—either by telephone (313/764-1366) or with your response. A final summary and a complete analysis of the exercises will be sent to each respondent upon completion of the final round of information packages—expected to be round four. A seminar will be held at the University of Michigan to review the output of the Delphi exercises.

It is requested that you respond to this letter as soon as practical but not later than . The procedures are sufficiently flexible that you may miss a round and still be represented in the final results.

John D. Ludlow
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University of Michigan

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