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ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

PLAN OF STUDY

PART C : VOL III
ENVIRONMENTAL APPENDIX

SEPTEMBER 1979

ACRES AMERICAN INCORPORATED

In Association with:

COOK INLET REGION INC. / HOLMES & NARVER INC.
R&M CONSULTANTS INC.
TERRESTRIAL ENVIRONMENTAL SPECIALISTS INC.
FRANK MOOLIN & ASSOCIATES INC.
SALOMON BROTHERS
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PREFACE

This volume consists of detailed plans of study for each of the major environmental disciplines to be investigated for the Susitna Hydroelectric Project. Only those environmental subtasks for which the scope statements are either too lengthy or too technical for presentation in the main proposal volume are included in this technical appendix. Summaries of these subtask scope statements and all other environmental subtasks, as well as an overview of the environmental analysis, are presented in Section A.5.8 - Environmental Studies in Volume I of the proposal. Personnel qualifications and responsibilities, the environmental studies schedule, and costs are also presented in other volumes.

As described in Section A.5.8 the environmental analysis will be performed in two phases. The first phase consists of pre-license application studies and will culminate in the preparation of an environmental report (Exhibit E) for submission to the Federal Energy Regulatory Commission (FERC). The second phase involves continued analysis to be performed in each discipline during the period of license application review. The results of the second phase studies will be presented in supplementary environmental reports. The subtask descriptions in this technical appendix span both phases of the analysis. For a explanation of what is to be performed in each of the two phases, please refer to the Subtask Scope Statements in Section A.5.8 and Section A.6 in Volume I.

For the purposes of designing thorough plans of study, however, a two-dam scheme in the upper Susitna River basin (Watana and Devil Canyon) was assumed. If another scheme emerges as the primary alternative, the environmental studies will be modified accordingly.

Acknowledgement should be accorded to the subcontractors who provided Acres and TES with plans of study that form the basis of the subtasks described in this technical appendix. The environmental analysis will be performed largely by these exports. In the order in which their disciplines are presented, we wish to thank:

Frank Orth & Associates Bellevue, Washington	Socio-economic Analysis
Dr. E. James Dixon, Jr. & George S. Smith University of Alaska, Fairbankns	Cultural Resources
Dr. Alan Jubenville University of Alaska, Fairbanks	Land Use Analysis and Recreation Plan
Milio C. Bell Mukilteo, Washington	Fisheries Analysis (Physical Factors)
Clinton E. Atkinson Seattle, Washington	Fisheries Analysis (Anadromous Fisheries)

Dr. Philip S. Gipson Alaska Cooperative Wildlife Research Unit, Fairbanks	Wildlife Ecology (Furbearers)
Dr. Brina Kessel & Stephen O. MacDonald University of Alaska, Fairbanks	Wildlife Ecology (Birds & Non-game Mammals)
Dr. Jay D. McKendrick & Dr. William W. Mitchell University of Alaska Agricultural Experiment Station, Palmer	Plant Ecology
DR. John J. Koranda Livermore, California	Plant Ecology

We also wish to express our gratitude to Dr. Samuel Harbo, University of Alaska, for his advise and technical guidance during the preparation of the wildlife ecology section of this Plan of Study.

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SUBTASK 7.05
SOCIO-ECONOMIC ANALYSIS

INTRODUCTION

An important element of the feasibility of the Susitna Hydroelectric Project is the socio-economic impacts created by its presence. Such impacts are important not only in their own right but also because of the intense socio-economic concerns so prevalent in Alaska. The intensity of these concerns was recently voiced as the proposed Rampart Project on the Upper Yukon River was defeated. This project was not undertaken in large part because the home-land of the Interior Natives, areas of habitat for caribou and other game animals, and up-stream and down-stream fisheries would have been adversely affected.

The purpose of this proposed study is to investigate in detail the socio-economic impacts associated with the Susitna Hydroelectric Project. The analysis is responsive to the current set of Federal Energy Regulatory Commission (FERC) license application requirements, but is scheduled to be implemented in two phases to comply with the anticipated changes in these requirements. Phase I consists of the pre-license application studies; Phase II consists of post-license application studies. The socio-economic plan of study was developed, and would be implemented, by Frank Orth & Associates. Below is a detailed presentation of the proposed study.

SCOPE OF WORK

A. GENERAL FRAMEWORK FOR PLAN OF STUDY

The primary objective of this study is to provide socio-economic studies of sufficient breadth and depth to meet FERC license application requirements. To meet these requirements the following tasks must be accomplished: (1) identify and evaluate significant socio-economic Project impacts and (2) assess the social and economic significance of the Project's impacts. These tasks are presented in Figure 1 in the boxes labeled 8, 6-A, 6-B, and 9. It should be noted here that particular emphasis is placed on assessing the significance of fish and wildlife impacts from commercial, recreational and subsistence perspectives. These assessments are emphasized because it is anticipated that they will be important elements of the socio-economic impact study.

To accomplish the above tasks, it is desirable to divide the study into two phases. The first phase consists of tasks designed to identify important socio-economic conditions which are likely to be impacted by the Project. Based on the findings of Phase I, in-depth analyses and assessments of potential Project impacts are performed in Phase II. The division of tasks insures that only the most relevant impacts are addressed. The effort saved from not studying irrelevant impacts may therefore be allocated to providing in-depth analysis and assessment of important impacts.

Phase I is composed of four tasks. The enumeration of these socio-economic study tasks and subtasks is not to be confused with the task breakdown of the overall feasibility study. The first socio-economic task furnishes background information for the development

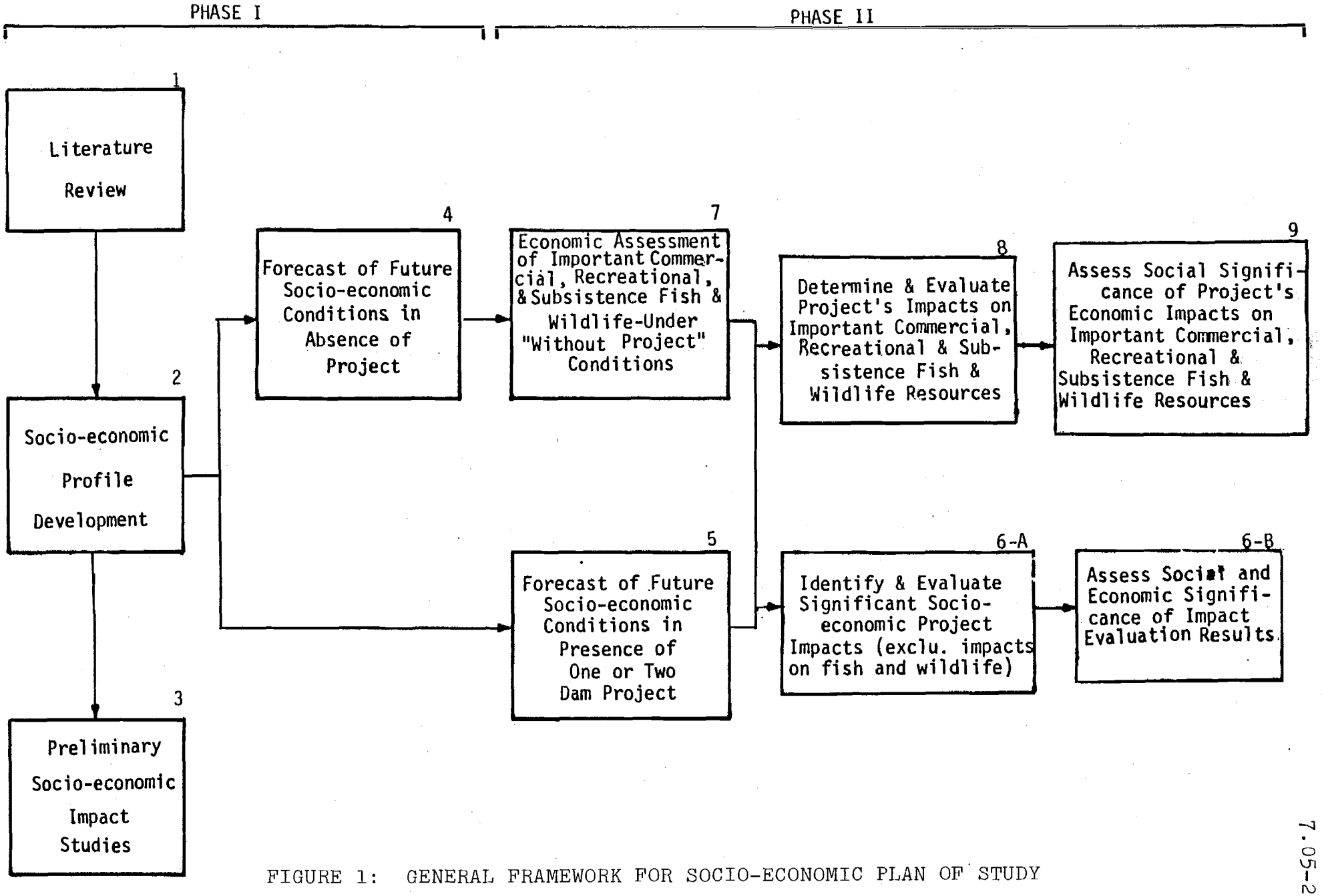

FIGURE 1: GENERAL FRAMEWORK FOR SOCIO-ECONOMIC PLAN OF STUDY

7.05-2

of detailed socio-economic conditions (Task 2). Next, the profiles are used in two ways: (1) to provide information for the screening of alternative types of hydroelectric projects (Task 3) and (2) to provide guidance in the selection of socio-economic conditions to forecast (Task 4). This guidance insures that only the conditions most likely to be impacted by the project are forecast. The future socio-economic conditions "without hydroelectric development" are forecast to serve later as a baseline for comparison.

In Phase II future socio-economic conditions "with hydroelectric development" are forecast (Task 5); the type of hydroelectric development is determined, in part, by the screening process of Task 3 (Footnote 1). Changes in conditions from the first scenario ("without development") to the second scenario ("with hydroelectric development") are identified and evaluated in Task 6-A. Task 8, similar to yet more detailed than Task 6-A, focuses on the project's impact on fish and wildlife. An assessment of important fish and wildlife resources is conducted in Task 7 in support of Task 8. Finally, the social and economic significance of the project's impacts are assessed (Tasks 6-A and 9).

B. OUTLINE SUMMARY OF THE PROPOSED SCOPE OF WORK

Exhibit 1 summarizes the proposed scope of work for this study. The tasks mentioned above are divided into subtasks and intermediate products resulting from several of these subtasks are identified.

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1. Alternative projects are run through other screens as well. The final selection of a hydroelectric development project is determined by synthesizing the screens in some manner to produce one project for further consideration.

EXHIBIT 1: OUTLINE SUMMARY OF THE PROPOSED SCOPE OF WORK

PHASE I:

TASK	SUB-TASK	PRODUCT
1. Literature review	a. Identify socio-economic impact studies for similar hydroelectric projects (include foreign studies)	1-a. List of socio-economic impact studies for similar hydroelectric projects
	b. Determine the nature and extent of studies' impacts	1-b. Table showing socio-economic impacts, by project, type, and degree
	c. Review general socio-economic conditions in the Local and Generalized areas[1], and State of Alaska	1-c. Draft profiles of socio-economic conditions, by Areas and State
	d. Assess relevance of studies' impacts for Local and Generalized areas, and for the State of Alaska	1-d. Partial list of potential Susitna Project impacts, by Areas and State
2. Socio-economic profile development	a. Identify potential impacts peculiar to the Local and Generalized areas, and the State	2-a. Table showing potential Susitna Project impacts, by Areas and State
	b. Determine conditions[2] most likely to be impacted, by Areas and State	2-b. Table showing conditions most likely to be impacted, by Areas and State
	c. Develop data collection guides	
	d. Collect data and information on most vulnerable conditions at Area and State level	
	e. Compile data and information	

1 The Local Area is in the immediate vicinity of the Project while the generalized area includes the region surrounding the Local Area as well as the Fairbanks/Tanana and the Anchorage/Cook Inlet regions.

2 Conditions will be described by social and economic variables such as population, per capita income, employment, etc.

TASK	SUB-TASK	PRODUCT
	f. Develop profiles of socio-economic conditions likely to be impacted, by Areas and State	2-f. Profiles of socio-economic conditions likely to be impacted, by Areas and State
3. Preliminary socio-economic impact studies	a. Identify conditions most likely to be impacted, by alternative, and Areas and State	3-a. Table showing most vulnerable conditions by alternative, and Areas and State
	b. Determine the nature and degree of potential impacts, by alternative, and Areas and State	
	c. Compare and contrast impacts of alternative projects, by alternative, Areas and State	3-c. Table showing nature and degree of impacts, by alternative, and Areas and State
4. Forecast of future socio-economic conditons in absence of Susitna Project	a. Identify studies which forecast socio-economic conditions in Alaska in the absence of significant hydroelectric power development	4-a. List of socio-economic conditions forecast studies
	b. Select studies which have geographically disaggregated results for further consideration	4-b. List of socio-economic conditions forecast studies with significant geographical disaggregation
	c. Develop and apply study methodology evaluation criteria	
	d. Select study(s) and study(s) results for adoption	4-d. Partial forecast of future socio-economic conditions in absence of Susitna Project
or, if necessary:	e. Revise study(s) methodology to allow for proper geographic disaggregation and/or new factors of change	
	f. Implement revised methodology	4-f. Forecast of future socio-economic conditions in absence of Susitna Project

EXHIBIT 1: OUTLINE SUMMARY OF THE PROPOSED SCOPE OF WORK (continued)

PHASE II:

TASK	SUB-TASK		PRODUCT
5. Forecast of future socio-economic conditions in presence of one and/or two dam Project	a. Identify conditions most likely to be impacted, by Areas and and State, and Project phase	5-a.	Table showing conditions vulnerable to Project's implementation, by Areas and State, and Project phase
	b. Determine the nature and extent to which future socio-economic conditions, will be impacted by the Project's presence, by Areas and State, and Project phase	5-b.	Forecast of future socio-economic conditions in Project's presence, by Areas and State, and Project phase
	c. Compare and contrast forecasted future socio-economic conditions with and without the Project	5-c.	Table showing forecasted future conditions in the absence of the Project, incremental changes in these conditions in the Project's presence, and future conditions in the presence of the Project
6. Identification and evaluation of significant socio-economic Project impacts	a. Determine which Project impacts create the largest and/or most important changes in the forecasted future socio-economic conditions without the Project	6-a.	List of large and/or important Project impacts
	b. Develop criteria (consistent with Exhibit W) for evaluating the impacts		
	c. Apply evaluation criteria	6-c.	Impact evaluations (text supported by, perhaps, tables)
	d. Assess social and economic significance of impact evaluation results (excluding the significance of fish and wildlife impacts)	6-d.	Application of results (text supported by, perhaps, tables)

EXHIBIT 1: OUTLINE SUMMARY OF THE PROPOSED SCOPE OF WORK (continued)

TASK	SUB-TASK	PRODUCT
7. Assess economic aspects of important commercial, recreational, and subsistence fish and wildlife under "without project conditions"	a. Identify fish and wildlife recources of significant or potential economic value	7-a. List of significant or potentially high-value fish and wildlife resources, by species or species-groups, and Areas
	b. Identify, review, and assess existing empirical fish and wildlife resource valuation studies; adopt valuations for important resources as appropriate	7-b. Partial list of resource valuations for significant or potentially high-value fish and wildlife resources, by species or species-groups, and Areas
	c. Develop methodology to valuate remaining economically significant resources	
	d. Implement methodology	
	e. Combine results from existing empirical studies and new empirical study	7-e. Table showing resource valuations for significant or potentially high-value fish and wildlife resources, by species or species-groups, and Areas
	f. Address unquantifiable dimensions of valuations; support quantitative findings as appropriate	7-f. Amendments, in tabular form, to the table in 7-e above
8. Determination and evaluation of Project impacts on important commercial, recreational, and subsistence fish and wildlife resources	a. Obtain information concerning biological and environmental impact of Project on important resources	

EXHIBIT 1: OUTLINE SUMMARY OF THE PROPOSED SCOPE OF WORK (continued)

TASK	SUB-TASK	PRODUCT
	b. Determine economic impact of Project (changes in resource value) on resources	8-b. Table showing changes in fish and wildlife social net present values, by species or species-group and Areas
	c. Address unquantifiable dimensions of valuations; support quantitative findings as appropriate	8-c. Amendments, in tabular form, to the changes in social net present value table
	d. Compare and contrast quantified economic valuations "with and without" Project	8-d. Text discussion supported by, perhaps, a table
	e. Compare and contrast quantified and qualified economic valuations "with and without" project	8-e. Text discussion supported by, perhaps, a table
9. Assessment of the social significance of Project economic impacts on important commercial, recreational, and subsistence fish and wildlife resources	a. Identify and determine minimum resource conditions and/or standards for commercial, recreational, and other interests	9-a. Table showing minimum resource conditions and/or standards, by interest group and species or species-group
	b. Compare the resource standard and/or condition acceptable to each interest group to the expected resource condition following Project implementation	9-b. Comparison table
	c. Discuss the social significance of comparison results	9-c. Text discussion
10. Preparation of reports	a. Develop Procedures Manual containing detailed work plan and production schedule for each task	10-a. Procedures Manual
	b. Develop outline for reports	

TASK	SUB-TASK	PRODUCT
	c. Select intermediate products for reports, as appropriate	10-1. Procedures Manual 10-2. Monthly Progress Reports 10-3. Draft Summary of Tasks 1-4 10-4. Final Summary of Tasks 1-4 10-5. Draft Summary of Tasks 5-9 10-6. Final Report
	d. Integrate intermediate products into reports, write reports, and produce reports	
11. Project management		
12. Task management		

APPROACH

A. DISCUSSION OF STUDY DESIGN

The study is designed to make efficient and effective use of existing literature, studies, models and highly qualified researchers with socio-economic impact analysis and Alaska experience. The first three elements serve to provide basic information, relevant methodologies and reduce the likelihood of duplicative effort. The last element contributes toward insuring that the most appropriate data bases are accessed, the most suitable methodologies applied, and that the results are evaluated and applied in a manner which supports the objectives of the overall project.

The study is also designed to insure that FERC license application requirements are adequately addressed. Tasks 1-9 of Figure 1 cover, in a general manner, all the FERC requirements as set forth in Exhibit W. (Footnote 1). Further, subtasks associated with Tasks 1-9 respond directly to the following components of Exhibit W:

2.3, 3.1.3, 3.2.3, and 7.3 Socio-economic Considerations
5.1 Human Resources Impacted

The methods employed in the subtasks develop most fully those socio-economic considerations which are relevant for the proposed project and its potential impact on the Alaskan environment. Utilization of this approach will produce results which are responsive to FERC license application requirements as well as to the needs of the citizens of Alaska.

Finally, the study is designed to be performed over a three and one-half year period. At the end of this period sufficient information will have been generated to meet the socio-economic requirements of the FERC license application. Should unexpected problems arise which impede the performance of critical tasks of this study, they will be analyzed and solved as quickly as possible. The only type of problem not having the potential for rapid resolution is that involving nature and the environment. (Footnote 2).

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1. Exhibit W of FERC Order nos. 415 and 415-C. Under the anticipated revision of FERC regulations, these items will be incorporated into Exhibit E and/or supplemental environmental reports.

2. An example of this type of problem would be a previously unresearched natural resource of potentially high economic value or significance. If environmental specialists were not able to provide adequate information within the three and one-half year period for a comprehensive economic assessment, then a preliminary assessment would be made for the FERC license application. If this information were challenged, or if a refined assessment were of significant interest, then the preliminary assessment could be revised subsequent to application for the license.

At present, no problems of this type have been identified. This does not mean, however, that this situation will not arise during the study. If this type of problem does arise, an attempt will be made to produce results (although some may be of a tenative nature) within the three and one-half year period. The study can be easily adapted to produce final results when sufficient information becomes available.

B. DISCUSSION OF ANALYTICAL METHODS FOR INDIVIDUAL TASKS AND SUBTASKS

Discussion in this subsection focuses upon subtasks from the Outline Summary of the Proposed Scope of Work (Exhibit 1) which require further explanation. Subtask approach and methods, and the relation among subtasks within a task are the main topics developed.

PHASE I:

1. Literature Review

a. Socio-economic impact studies for hydroelectric projects similar to the range of proposed projects for the Susitna vicinity will be identified. A subcontractor with extensive familiarity with socio-economic studies will be provided with a data compilation format. The purpose of this format will be to acquire data concerning the subcontractor's past work in socio-economic impact analysis. In addition the subcontractor will be relied upon to furnish suggestions regarding strategies for further identification of relevant studies.

Bibliographies and major entities such as the Army Corps of Engineers will be consulted to identify further hydroelectric studies. It is anticipated that the major source of bibliographies will be those found in the studies initially identified.

b. All studies will be placed in a similar data format to facilitate extraction of impacts, by nature and degree. The format will be developed, studies will be reviewed, and the format will be implemented. Data particularly relevant to Alaska will be highlighted in the format.

c. General socio-economic conditions in the local area (immediate vicinity of the range of alternative dam sites), the region (the area surrounding the immediate dam-site vicinity and the Fairbanks/Tanana and Anchorage/Cook Inlet regions) and the State will be reviewed. This review will include:

- a review of current major assessments of Alaska economic conditions, by region;
- a review of literature pertaining to the Alaska social/cultural environment; and
- interviews with recognized authorities on Alaska economic and social conditions, including but not limited to:

Dr. David Reaume, Alaska Department of Commerce and Economic Development

Mr. Bob Richards, National Bank of Alaska

Dr. David Kresge, Harvard University and The Institute of Social and Economic Research, University of Alaska

Finally, profiles of general socio-economic conditions will be developed with local, regional, and state geographic orientations.

d. The relevance of impacts, identified and characterized in 1b., for the State of Alaska will be assessed at local, regional, and state levels. This assessment will yield a list of impacts, by geographic area, type and degree, which may be relevant for the Susitna Project impact studies.

2. Socio-economic Profile Development

The purpose of this task is to develop detailed profiles of socio-economic conditions most likely to be impacted by a broad range of alternative Susitna dam projects. Attention is focused only on those conditions (Footnote 1), which are highly vulnerable.

a. Potential impacts peculiar to the local area, region and state will be determined. This list of impacts will be combined with those of 1d. to provide a complete list of potential impacts for the broad range of alternative projects.

b. Next, potential impacts on the list will be assessed for their relevance to the Susitna Project at the local, regional, and state levels. Some of the less relevant potential impacts will drop out; what will remain is a list of socio-economic conditions most likely to be impacted by the broad range of alternative Susitna projects.

c. Data collection guides will be developed to gather information necessary to support the production of detailed profiles of socio-economic conditions most likely to be impacted.

d. Data collection guides will be implemented; information will be gathered at local, regional, and state levels.

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1. Socio-economic conditions will be described by social and economic variables. The range of variables considered for the impact analyses will include at the minimum the variables mentioned in Exhibit W, components 2.3, 3.1.3, 3.2.3, 5.1, and 7.3. Only those relevant for the Susitna Project will remain for treatment in subsequent tasks. Reasons for eliminating variables from Exhibit W set will be elaborated.

e. Information will be compiled in a format conducive to profile development.

f. Detailed profiles will be developed from the information presented in e. above and also from the general profiles developed in 1c.

3. Preliminary Socio-economic Impact Studies

Other Susitna Project Team members will provide a narrow range of alternative dam projects. There will be substantial physical specification and other information made available on each alternative project by these team members.

a. Socio-economic conditions most likely to be impacted will be identified for each alternative, by local area, region and state. Extensive use will be made of the table developed in 2b. above showing conditions most likely to be impacted by the broad range of alternative projects.

b. The nature and degree of potential impacts will be determined for each alternative by local area, region, and state. Potential impacts for each alternative will be shown in matrix form at local, regional, and state levels of geographic aggregation. To the extent physical and other information allow, an attempt will be made to show impacts by project phase. (Footnote 2). To arrive at potential impacts, the economic and social implication of each alternative will be determined quantitatively, by qualitative inference, and/or qualitatively. The nature and degree of potential impacts will also be determined by project phase to the extent physical and other information allow.

c. The impacts of alternative projects will be presented in matrix form by local area, region and state. This form of results presentation will be useful in screening the alternative projects for socio-economic considerations.

4. Forecast of Future Socio-economic Conditions in the Absence of the Susitna Project

a-f. Studies and methods for forecasting Alaska socio-economic conditions will be identified and investigated by interacting with knowledgeable public and private economists. A list of studies and forecasting approaches will be developed. Next the studies will be evaluated using, at the minimum, the following criteria:

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2. Each alternative dam project has 4 phases:
   Testing
   Conceptualization and Design
   Construction
   Operating

1. appropriate geographic disaggregation of results;
2. appropriate methodology;
3. appropriate conditions (variables) are forecast; and
4. study is current.

It is anticipated that few if any of the existing studies will pass all four of the criteria. It is highly likely that geographic disaggregation will be inappropriate and/or that the "wrong" variables or too few variables are forecast. To rectify the situation, the chosen methodology(s) will be modified to be consistent with the remaining criteria. The revised methodology(s) will be implemented to produce a baseline forecast of socio-economic conditions.

PHASE II:

5. Forecast of Future Socio-economic Conditions in Presence of One and/or Two Dam Project

Other Susitna Project Team members will provide detailed information concerning the chosen alternative (i.e., the hydroelectric project chosen).

a. Socio-economic conditions most likely to be impacted will be identified by local area, region, and state, and Project phase. Extensive use will be made of the tables developed in 2b. and 3a. above.

b. The nature and extent to which future socio-economic conditions (see 4f. above) will be impacted by the Project, will be determined by local area, region, and project phase. One of the three following methodologies will be employed:

i. Determine impacts of the project on variables of concern, at local area, region, and state levels. Quantify impact on variables directly, or through qualitative inference. In cases where neither of these techniques is possible, qualitatively estimate the impact. Combine these estimates of project impact with the baseline of 4f.

ii. A forecast of future conditions "with the project" could be generated by running the model chosen in 4 above. The algebraic difference of the model runs "with" and "without" the project would represent the impacts.

iii. Neither of the above. It is very difficult to determine at present which methodology will be most appropriate. This is the reason i and ii above are not devleoped further. The choice and development of methodology for this part of the analysis will be made after Task 4 has been completed.

c. Future socio-economic conditions "with" and "without" the project will be compared and contrasted in a matrix format.

6. Identification and Evaluation of Significant Socio-economic Project Impacts (excluding impacts on fish and wildlife resources)

a-d. Criteria to evaluate the impacts will be developed. These criteria will be applied to the results in a systematic manner to yield impact evaluation results for each phase of the project. These results will be discussed in depth and then assessed for social and economic significance. This assessment will include consideration of impact significance from local and regional and state perspectives.

The assessment will focus on changes in population, employment, patterns of industrial growth, the needs for public services, and other elements of sections 3.1.3, 3.2.3, 5.1 and 7.3 of Exhibit W. Specific emphasis will be placed on (1) the effects of lower electricity rates on industrial growth, (2) other actions made economically feasible or precluded by the implementation of the Project and (3) public services required to support economic development in the region and state. The social significance of this development will also be addressed.

Examples of the above points of emphasis are the following:

i. The development of manufacturing and processing industries in Interior Alaska has been constrained in large part by the high cost of energy. Lower cost energy may allow some new industries to gain a foothold and other established industries to grow more rapidly. This industrial growth could have significant implications for population, employment, tax revenues, value of exports, etc.

ii. The transportation system created to provide access to the construction site(s) could provide opportunities for the recreation, tourism, and forest products industries, among others. These activities, infeasible without the project, could create significant employment opportunities as well as provide recreational and cultural benefits.

iii. Public services required to support i and ii above.

The development of criteria for the assessment of economic significance will include consideration of: (1) contribution to total employment; (2) enhancement of "off-season" employment opportunities; (3) contribution to tax base and per capita income, (4) contribution to value of exports; and (5) contribution to the diversification of the economic base. The development of criteria for the assessment of social significance will include consideration of: (1) employment and leisure-time opportunities and their effect on the social fabric; (2) effects of population change; and (3) the implications of precluding certain activities.

Suggestions will be offered regarding ways of mitigating the impacts through public or private actions. Also, ways in which the results can best be used to support the objectives of the overall project will be discussed.

7. Assess Economic Aspects of Important Commercial, Recreational, and Subsistence Fish and Wildlife Under "Without Project Conditions"

a. Fish and wildlife resources with significant existing or potential economic value will be identified by using internal knowledge and contacts, and consulting with other Susitna Project Team members. These resources will be identified by species or species-group and area. Areas will now be defined more narrowly than previously and will be specific to each species or species-group. The range of a directly impacted species' stock or population will be divided into 3 concentric rings, ellipses, or other, as appropriate.

b. Existing fish and wildlife studies will be identified and reviewed. Criteria will be developed to judge the acceptability of the study methodologies. Results from those studies which pass the test will be adopted. These valuations will serve as baseline conditions and will be extended into the future using appropriate methods.

c-d. Methodologies will be adopted from existing studies or modified to obtain valuations for important fish and wildlife resources not covered in the studies. (Footnote 1). These valuations will also be extended through time for comparability (to valuations of 6b above) and completeness.

e. Valuations from b and c-d above will be combined to obtain a set of valuations for important fish and wildlife resources.

f. Unquantifiable dimensions of the valuations will be addressed and used in support of the quantitative measures in order to more completely characterize resource values.

8. Determination and Evaluation of Project Impacts on Important Commercial, Recreational, Subsistence Fish and Wildlife Resources

a. Environmental specialists on the Susitna Project Team will provide biological and environmental impact information for potential use in deriving economic impacts.

b. Information supplied in a. will be translated into economic values. These values will be quantitative and a partial measure of the economic impact of the project on resources. The present

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1. For some resources this may not be possible or feasible.

value of the time stream of values "with" and "without" the project will be calculated for each species or species-group, by area (where possible).

c. The quantitative measures of economic impact in b. will be augmented by qualitative measures where quantitative measures are lacking or weak.

d. The present value streams of b. above will be compared to obtain the present value of economic impact by species or species-group, by area (where possible).

e. Qualitative measures will be used next to support the quantitative measures in d.

9. Assessment of the Social Significance of the Project's Economic Impacts on Important Commercial, Recreational, and Subsistence Fish and Wildlife Resources

a. Minimum resource conditions and/or standards will be determined for each user group. Past and present utilization rates and patterns will play a key role in determing the appropriate minimum conditions.

b. The minimum resource condition judged to be acceptable to each user group will be compared to the expected resource condition "with the project." Differences between these two types of conditions will be quantified to the extent possible.

c. The social significance of comparison results will be discussed.

C. SIGNIFICANCE OF EXPECTED RESULTS

Without an assessment of the expected impact of one's actions, it is quite difficult to decide whether or not the action is wise. If the expected disadvantages associated with the action outweigh the expected advantages to be gained, action would not be wise. Unfortunately, the assessment process is rarely so simple; problems emerge in defining advantages and disadvantages, estimating their magnitude, and judging whether one outweighs the other.

The decision to undertake any large project poses both technical and political problems. In government, which must frequently be reactive to disparate groups, the political aspects are generally most difficult. This study is designed to ease both the technical and political difficulties inherent in the decision making process.

This study will objectively describe, in quantifiable terms where appropriate, the expected socio-economic impacts associated with development of a hydroelectric facility on the Susitna River. A description of these impacts will aid in both the political and technical aspects of decision making and planning.

The impacts will describe the economic and social changes which will result from the proposed project. Descriptions will deal with areas such as the effects of a low cost and plentiful energy supply, alteration of the natural habitat, and forced social, cultural, and psychological changes. By developing and presenting such information a legislator or other political decision maker will be able to more easily decide which effects are advantages, which are disadvantages, and whether the former outweigh the latter.

By identifying the expected changes, the technical decision maker will also be helped. The proposed project may be modified in various ways to avoid or minimize identified changes perceived as disadvantages. If such avoidance or minimization is impossible, other ameliorative steps, outside of the proposed project itself, may be undertaken.

In summary, the development of socio-economic impact assessments will help the political decision maker by encouraging a rational political decision making process, and help the technical decision maker by allowing him to avoid or minimize problems through project modification, or ameliorate problems through other actions.

SCHEDULE

The production schedule for the socio-economic portion of the project is presented in Exhibit 2. Major tasks are listed in the left column and their period of performance, in months, on the right. The period of performance for individual subtasks within a task is indicated by lower case letters; these letters correspond to the subtasks of Exhibit 1.

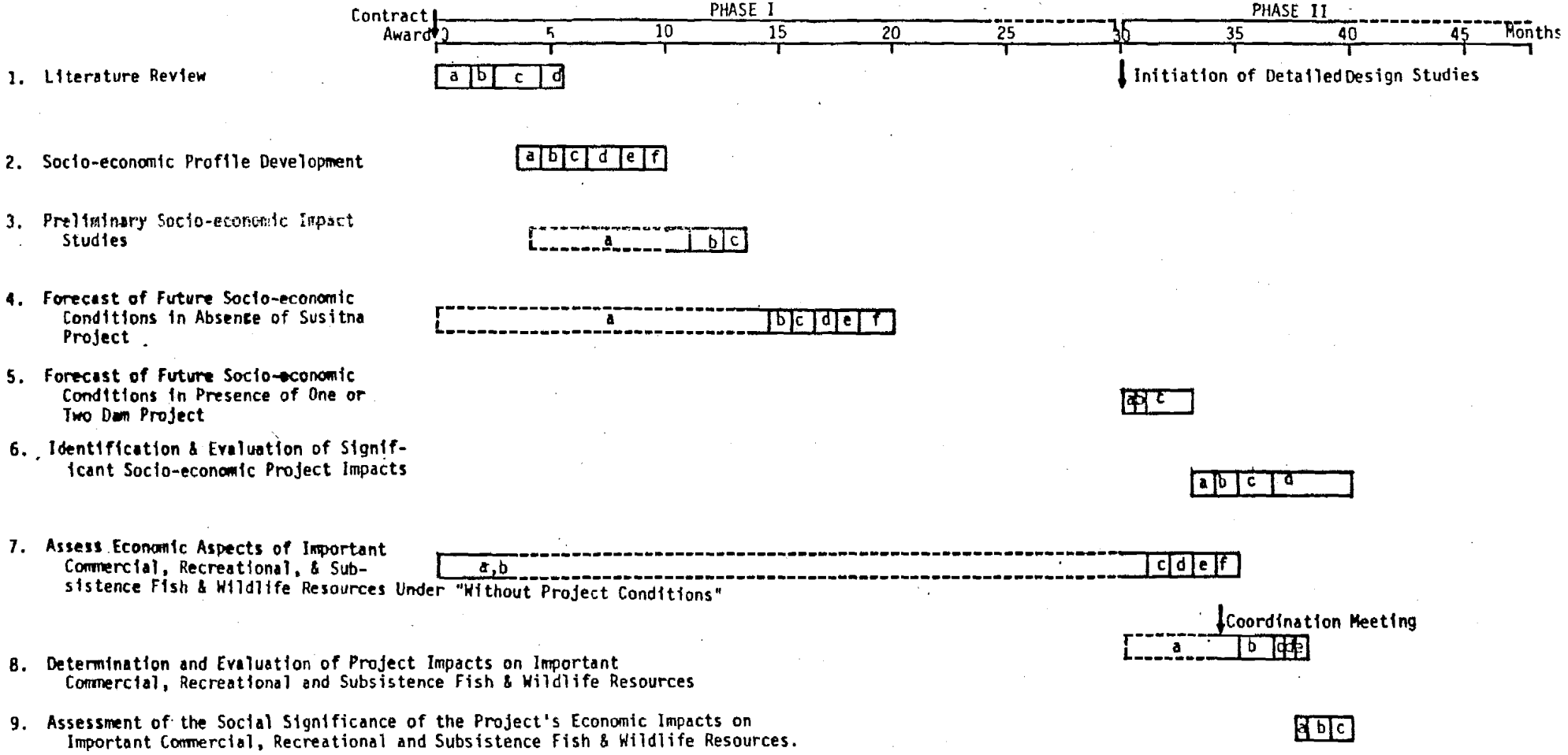

EXHIBIT 2: PRODUCTION SCHEDULE FOR SOCIO-ECONOMIC PLAN OF STUDY

GENERAL REFERENCES

1. Abbott, Jeanne, Pressure Builds Behind Susitna Dam, Anchorage Daily News, September 10, 1978.

2. Alaska Pacific Bank, Alaska Business Trends, Anchorage, Alaska, 1977.

3. Foster, Scott, Governor to Seek Legislative Funding For Devil Canyon Study, Office of the Governor Press Release, Juneau, Alaska, October 25, 1978.

4. Kresge, David T., Morehouse, Thomas A., Rogers, George W., Issues in Alaska Development, University of Washington Press, 1977.

5. State of Alaska Division of Economic Enterprise, Alaska Community Profiles.

6. State of Alaska Division of Economic Enterprise, The Alaska Economic Information & Reporting System Quarterly Reports, 1978-1979.

7. State of Alaska Department of Economic Development, A Performance Report of the Alaskan Economy, various volumes.

8. State of Alaska Department of Labor, Alaska Economic Trends, various issues.

9. State of Alaska Department of Labor, Economic Forecasts, 1976-1978.

10. University of Alaska, Institute of Social and Economic Research, Review of Business and Economic Conditions, 1971-1979.

11. US Army Corps of Engineers, Plan of Study for Susitna Hydropower Feasibility Analysis, June 1978.

12. US Army Corps of Engineers, Supplemental Feasibility Report: Hydroelectric Power and Related Purposes, February, 1979.

13. US Department of Energy, Alaska Power Administration, Power Market Analyses: Upper Susitna River Project, January 1979.

14. Weeden, Robert B., and Alaska Conservation Society, What are the Problems With the Susitna Hydropower Project?, A letter to Alaskan Legislators, February 29, 1979.

SUBTASK 7.06
CULTURAL RESOURCE ANALYSIS

INTRODUCTION

The following document is a proposal for the identification and mitigation of cultural resources which may be adversely affected by the proposed Susitna Hydropower facility. The proposal consists of sections which concisely discuss the major aspects of the proposal. The first two sections, Cultural Chronology and Cultural Resources in the Study Area, provide a brief synopsis of previous research relevant to the Susitna project. They are provided as introductory material and should not be regarded as an in-depth analysis of previous work, as they require considerable expansion for a research design. The following section, entitled Authority, defines and explains both state and federal legislation which is pertinent to the preservation of cultural resources which may be adversely affected by the Susitna project. The Scope of Work explicates how the University of Alaska Museum proposes to execute the project in a series of steps, and defines the activities of each step. The next section, Discussion of Steps, explains in greater detail what will be accomplished in each step. Section 6, Formulation of Research and Sampling Designs, provides an explanation of how the Museum will develop these tools to guide the inventory and mitigation measures. A brief description of the experience, qualifications, and project responsibilities of key Museum personnel who will be responsible for the research effort is also presented. This is followed by a bibliography.

The archaeological survey and excavation effort proposed by the University Museum is developed specifically for the Susitna Hydropower Project (Devil Canyon and Watana dams) as outlined in the Susitna Hydropower Plan of Study (1978) prepared by the Alaska District, U.S. Army Corps of Engineers. In the Corps' plan of study certain areas for the construction of dams, spillways, cofferdams, tailrace tunnels, power plants, gate chambers, switchyards, access roads, transmission routes, and reservoirs have been detailed. The University Museum's proposal is based on the above data, and any changes made in selection of construction areas or starting date of the environmental studies may also require changes in the Museum's proposal.

SECTION 1: CULTURAL CHRONOLOGY

The proposed project area is situated between interior Alaska and the coastal environment of Cook Inlet. Given such a geographic location it is not unreasonable to expect that the project area has been influenced by cultural developments and contacts from both the Alaskan Interior and the North Pacific Coast. Consequently, it is essential to consider both regions when developing a broad cultural overview for the study area. Dixon, Smith, and Plasket (1979, 23-25) have recently summarized the cultural chronology of interior Alaska as follows:

> The known prehistory of interior Alaska spans the past 12,000 years, and current research in this area (Dixon and Plasket 1978; Hoeffecker 1978) and the adjacent

Yukon territory in Canada (Irving 1978; Morlan 1978) suggests that early human occupation may have occurred more than 20,000 years ago. Three of the earliest dated interior sites that are older than 11,000 years, and in fairly close proximity to the project area include the Dry Creek and Moose Creek sites near Healy, and the Village Site at Healy Lake. As yet microblades have not been recognized in these early assemblages and their relationship to Denali is unclear.

Starting approximately 10,600 years ago, the Denali Complex (West 1967) appears in interior sites represented by Dry Creek, Donnelly Ridge, the Campus Site, the Village Site at Healy Lake, the Teklanika River sites, Batza Tena, and Girls Hill. This distinctive and long lasting stone tool industry is characterized by wedge-shaped microcores, microblades, core tablets, bifacial knives, Donnelly burins and burin spalls, and end scrapers. It has been suggested (Dumond 1978) that the Denali Complex is a regional variant of the Northern Archaic Tradition as defined by Anderson (1968a). The Denali Complex has been dated to between 8,600 and 4,000 B.C. in interior Alaska. There is a hiatus of Denali sites in the interior archeological record after 4,000 B.C., however several sites in the Tanana Valley which contain distinctive Denali elements date to between 2,400 B.C. and A.D. 1,000 and suggest a late persistence of this stone industry in this area.

Beginning approximately 6,000 years ago, peoples of the Northern Archaic Tradition (Anderson 1968b) appear to have expanded from Northern Alaska into the interior. This newly arrived tradition is in evidence at the Campus Site, Dry Creek Site, Ratekin Site, Teklanika Sites, and several sites near Tangle Lakes. The hallmark of this tradition is notched projectile points, but other elements include end scrapers, elongated and semi-lunar bifaces, boulder chip artifacts, large unifaces, notched pebbles, axes, hammerstones, and choppers. Northern Archaic-related sites are presently known to exist in the interior until about 1,400 B.C. Hypsithermal advance of the boreal forest has been correlated with the influx of the Northern Archaic Tradition (Anderson 1968b; Schwager n.d.). After 1,400 B.C., it is not clear, based on existing data, whether the Northern Archaic Tradition provided the basis for later northern Athapaskan material culture. Between 2,400 B.C. and A.D. 1,000 the archeological record is complex, but by A.D. 1,000 a major technological change had occurred in the interior with a de-emphasis on stone working. Several of these archeological assemblages after A.D. 1,000 can clearly be traced through time and linked to recent Athapaskan groups (Cook and McKennan 1970). Based on linguistic evidence (Krauss 1973), which suggests that 2,000 to

3,000 years of in situ development would be necessary to achieve the modern diversity in northern Athapaskan languages, and the late persistence of certain Northern Archaic Tradition traits, such as notched points after 1,400 B.C. (West 1973; Holmes 1975), it appears possible that the Northern Archaic Tradition continuity may extend to, and provide the basis for, the later identified interior Athapaskan archeological assemblages.

Interior Chronologies

Early Sites	10,000 B.C. or greater
Early Denali	10,000 B.C. - 4,500 B.C.
Northern Archaic/Late Denali	4,500 B.C. - A.D. 1,000
Late Prehistoric Athapaskan	A.D. 1,000 - A.D. 1,850
Historic	A.D. 1,850 - present

To the south of the Alaska Range pioneering archeological research in Cook Inlet and Kachemak Bay regions was accomplished by Frederica deLaguna during the summers of 1930, 1931 and 1932. DeLaguna's field work and subsequent analysis led to the delineation of several culture periods which preceded Tanaina Athapaskan culture in the Cook Inlet area. These culture periods were named from the oldest to the youngest: Yukon Island I, II, sub-III, III, and IV (deLaquna 1975:29). The Yukon Island sequence has become the type sequence for the Kachemak Tradition and most researchers now use the terms Kachemak I, II, and Sub-III when describing prehistoric material culture from the Cook Inlet region. These Kachemak Tradition culture periods are derived directly from deLaguna's Yukon Island sequence.

William Workman (1977) has attempted to establish a tentative chronological framework for the Kachemak tradition based on the relatively scanty radiocarbon data available for the Cook Inlet region. He (ibid.:33) suggests a second millennium A.D. temporal placement for the Kachemak IV, which he has added to deLaguna's three major period sequence. Kachemak IV period is as yet undated but represents a somewhat nebulous artifact assemblage containing native copper, triangular slate end blades, and potsherds. It may represent the remains of both post Kachemak tradition Pacific Eskimos and early Tanaina Athapaskans (ibid.). A temporal span between A.D. 800 through A.D. 0 is proposed for Kachemak III, A.D. 1,200 to 400 B.C. for Kachemak II, and Kachemak I is ascribed temporal placement to sometime during the second millennium B.C. (ibid.:34-35). DeLaguna has provided a concise summary of archeological field research undertaken between 1934 and 1975 in the Cook Inlet region, and readers are referred to her Preface to the 1975 reprint of "The Archeology of Cook Inlet, Alaska" (deLaguna 1975: iii-xi) for more detailed information.

Reger (1978) has reported a multicomponent site located on Turnagain Arm which has been named the Beluga Point Site. The site exhibits six cultural components, which are: (1) a microblade bearing component, (2) a stemmed point component, (3) a Kachemak III related component, (4) a Norton related component, (5) a lanceolate point

component, and (6) a level represented by a large scraper which has been radiocarbon dated to 4,155 B.P. (Reger 1978:1). Based on comparison with archeological materials from the Alaskan Interior, the microblade component, and possibly other components, may be related to archeological materials from Interior Alaska.

SECTION 2: CULTURAL RESOURCES IN THE STUDY AREA

A review of literature directly related to the history and prehistory of the study area as found in the Alaska Heritage Resource Survey and various published and unpublished reports indicates that six prehistoric and thirteen historic sites have been recorded within the study area. The apparent paucity of sites in this area may be attributed to the fact that little archeological research has been carried out in the study area, although both Irving (1957) and Bacon (1978) have conducted limited archeological surveys in the region. In surrounding areas where archeological research has been more intensive, the number of sites documented is considerably higher. In the eight (8) U.S.G.S. quads surrounding the study area, 630 historic and prehistoric sites have been documented.

Sites in the study area and surrounding region can effectively be organized into the chronologies outlined in the previous section. More specific in terms of the Late Prehistoric Athapaskan and Historic periods are activities related to trade prior to white contact, early exploration, the fur trade industry, gold mining, and the railroad. These activities would all have had an effect on the location of historic and prehistoric sites within the study area.

Because of the minimal quantity of data available on the cultural resources within the study area, the reconnaissance and intensive surveys developed for this study are of paramount importance in identifying cultural resources and providing the appropriate recommendations as required by law.

SECTION 3: AUTHORITY

As the Susitna Hydropower Project is a federally licensed project for the State of Alaska, the legal framework and authority for the consideration of cultural resources are spelled out in a number of federal and state regulations. As early as 1906 the Antiquities Act (P.L. 59-209) directs the preservation of cultural resources on public lands. The Historic Preservation Act of 1935 (P.L. 74-292) requires the preservation of properties "of national historical or archeological significance and authorizes interagency, intergovernmental, and interdisciplinary efforts for the preservation of such resources." The Reservoir Salvage Act of 1960 (P.L. 86-523) provides for the recovery and preservation of "historical and archeological data" that might be lost or destroyed as a result of the construction of federally funded or licensed dams, reservoirs, and attendant facilities and activities. This law was extensively amended in 1974. The Historic Preservation Act of 1966 (P.L. 89-665) declares it to be a national

policy to preserve and protect historic and prehistoric sites, buildings, and objects of natural significance. Continuing with this policy the National Environmental Policy Act of 1969 (P.L. 91-180) requires evaluation of the effects of major federal actions on the environment including cultural resources. The Archeological and Historic Preservation Act of 1974 (P.L. 93-291) is an amendment to the Reservoir Salvage Act of 1960. The 1974 Act provides for the protection of historic and archeological sites

> ...which might otherwise be irreparably lost or detroyed as a result of (1) flooding, the building of access roads, the erection of workmen's communities, the relocation of railroads and highways, and other alterations of terrain, caused by the construction of a dam by any agency or (2) any alteration of the terrain caused as a result of any federal construction project or federally licensed activity or program (Sec. 1).

Section 7 of the Act authorizes that up to 1% of the total budget of a federally funded or licensed project may be allocated for archeological survey, recovery, analysis and publication. Executive Order 11593 directs all federal agencies to make an inventory of historic and prehistoric properties under their control and to nominate eligible properties to the National Register of Historic Places, and to give priority inventory to federally owned properties to be transferred and/or altered. As the Army Corps of Engineers are involved in this project at this point in the negotiations, Army Regulation AR 200-1, Environmental Protection and Enhancement (1975), Chapter 8 -- Historic Preservation, also applies. This regulation is a general policy statement (8-4) of the Department of the Army directing that cultural resources be located, inventoried, evaluated and qualified sites be nominated to the National Register of Historic Places.

The Alaska Historic Preservation Act of 1975 reflects the same spirit concerning cultural resources as the above federal regulations. It is the general policy of the State of Alaska that before any construction or public improvement of any nature is undertaken by the state, by a governmental agency of the state, or by a private person under contract with or licensed by the state, that the cultural resources must be considered.

SECTION 4: SCOPE OF WORK

The preceding section (entitled "Authority") clearly defines what cultural resource preservation efforts are required by federal and state law to satisfy licensing requirements for the Susitna Hydropower Project. These tasks include at minimum: (1) Identification and documentation of cultural resources within project areas, (2) formulation and explication of recommendations for mitigation for each historic or archeological site identified. However, it is also recognized that the initial studies essential to meet licensing requirements may have direct impact on cultural resources which may pose immediate adverse effects. Examples of such

activities are construction of camps to house study personnel, test holes to locate proposed borrow areas, access roads to study locales, etc. Any proposal to identify cultural resources and make recommendations for preservation must be structured in such a fashion as to permit mitigation of potential damage to archeological and historic sites during the course of the impact study. If such mitigation procedures are not incorporated in to the proposed action for historic preservation, needless delays and unnecessary additional costs will be inevitable. This has been repeatedly demonstrated in other large construction projects which have required the identification and mitigation of cultural resources for licensing. This proposal foresees this need and provides methods by which these delays can be avoided. The proposed historic preservation efforts should be conceptually divided into (1) the effort necessary to obtain the license, (2) effort necessary to mitigate possible adverse effects during the course of the study essential to obtain the license, and (3) effort necessary to mitigate damage to all historic and prehistoric sites that will be impacted by the construction phase.

The University Museum will execute a five-step research effort specifically tailored to satisfy both state and federal legislation pertinent to cultural resources as necessary to satisfy licensing requirements and to conduct the related studies also required for licensing.

The five steps are:

1) Step I — Essential prefield season tasks, literature review, analysis of the data base, development of a research design and sampling strategy. Recruitement of personnel and staging for field work, application for necessary permits.

2) Step II — Reconnaissance level archeological survey of project areas based on priorities determined by the sequence of construction events. The needs of the specific study teams engaged to satisfy licensing requirements will obtain highest priority. It is impossible at this point to project temporal and fiscal requirements for mitigation efforts for adversely affected sites during the course of pre-license studies. Mitigation efforts, if required, will be conducted on a cost reimbursable basis during this step.

3) Step III — Intensive testing of archeological and historic sites discovered during Step II. This testing effort is essential to determine both the horizontal and vertical dimensions of specific sites, and to estimate reasonably accurately the kinds of materials contained within them. This information is necessary to delineate mitigation measures for any sites potentially subject to adverse effects. Step II tasks may continue simultaneously with Step III activities.

4) Step IV — Final report preparation. The final report will at a minimum provide the location and description of every archeological and historic site recorded during the course of the study. It will also provide recommendations for mitigating adverse effects to sites which may be subject to disturbance or destruction during construction activities based upon the data derived from Steps II and III.

5) Step V — All recovered artifactual material and supporting documentation will be deposited with the University of Alaska Museum and will be retained as public information within the State of Alaska. The collections and supporting documentation will be curated in accordance with state and federal requirements pertinent to the preservation of antiquities.

It is recognized that effective historic preservation efforts must be coordinated with other aspects of the Susitna Hydropower Project. The University Museum will make every reasonable attempt to anticipate the needs of the project pertinent to cultural resources. However, it will be the responsibility of the prime contractor to coordinate between subcontractors and to provide the scheduling information essential to successfully anticipate and to deal effectively with these needs.

SECTION 5: DISCUSSION OF STEPS

STEP I -- PREFIELD SEASON TASKS

Prior to initiating field investigations during the summer of 1980, the University of Alaska Museum will execute the following tasks:

1) Apply for, and secure a Federal Antiquities Permit and and state documents that may be necessary for the archeological portion of the project. (Office of Archeology and Historic Preservation, Interagency Services Division, National Park Service, U.S. Department of the Interior, Washington, D.C. 20240; State Archeologist's Office, State of Alaska, Department of Natural Resources, State Division of Parks, Anchorage, Alaska).

2) Conduct an exhaustive literature review of available documents that pertain to the history, prehistory, ethnography, geology, flora, fauna, and late Pleistocene and Holocene geology of the areas covered by this project. Museum staff will utilize the resources of the University of Alaska Library and Archives, data files of the University Museum, and records at the State Office of History and Archeology. Consultation with other professionals who have worked in or have knowledge of the study area will be utilized as necessary.

3) The results of the literature search will be used to synthesize the regional and local cultural chronology of the study area as well as to provide the basis for the research design.

4) Air photos of the study area will be examined and their interpretation will focus on the identification of probable areas containing cultural resources.

5) Known historic and archeological sites will be plotted on 1:63,360 scale maps. Each resource will be specifically identified. A preliminary aerial reconnaissance of the project area will be conducted.

6) Utilizing the information base produced by the above research, a research design will be developed to include a sound professional sampling strategy specifically designed for the unique needs of this project.

7) Following formulation of the research design and sampling designs, the Principal Investigator and Project Supervisor will recruit essential personnel for the field portion of this project.

It is estimated that these prefield season tasks will take approximately five months. Upon completion of the prefield tasks (Step I), the necessary personnel and data base will be utilized for the reconnaissance level survey (Step II), and for mitigation of adverse effects on cultural resources which may possibly be affected as a result of the licensing study.

STEP II -- ARCHEOLOGICAL RECONNAISSANCE

The purpose of this step is to identify, locate, and inventory archeological and historic sites. These sites will later be subject to more intensive study. As specified in 36 CFR 66 in the Federal Register, Vol, 42 No. 19, a reconnaissance level survey should be used only as a preliminary tool prior to intensive survey. The information gathered during Step II of this project will form the data base for intensive survey in Step III.

As it is not the intent of a reconnaissance level survey to cover 100% of the study area, preselected areas identified in the research design (Step I) will be selected for survey. Within these areas field crews will implement surface and subsurface testing procedures in order to locate, document, and inventory historic and prehistoric sites that may occur in the study area. This site-specific data will be used to develop and direct Step III studies. Aerial reconnaissance will also be conducted at the preselected areas in order to enhance site location during Step II. Available aerial photographs, as well as LANDSAT photos, will be reviewed for all preselected areas in order to aid in locating potential site areas.

During Step II the dam impoundment areas and associated facilities will be field surveyed. The proposed primary transmission route will be field surveyed at a later date.

Based on both state and federal guidelines as discussed in an earlier section, it is possible that preconstruction studies may have an adverse impact on cultural resources. These include, but are not limited to, the installation and operation of seismic monitoring systems, the examination of foundation conditions for access roads, geological and soil studies, clearing and surveying for access roads and transmission lines, borrow pit exploration and testing, geophysical subsurface investigations, exploration and testing for dam site locations, testing in association with the construction of an airstrip, construction of access roads into the study area, movement of heavy equipment into and within the study area, or any other preconstruction activities that would create subsurface disturbances and hence have the potential of destroying cultural resources.

During Step II every effort will be made to work with other professionals involved in the Susitna Hydropower Project, to see that an archeological survey is conducted early in each ground disturbing activity so as to be compatible with the needs of other portions of the project. If any archeological sites are found during the course of the survey in areas slated for subsurface disturbance during preconstruction activities, it will be necessary to undertake immediate mitigating measures.

All archeological and historical sites that will be adversely impacted by the licensing study for this project will be mitigated in connection with the regulations of the Advisory Council on Historic Preservation. These measures include avoidance, preservation, and excavation. If excavation is recommended then it will be necessary to deploy a crew to each site specified for this procedure. As it is not known how many and how large these sites might be, a line item for excavation cannot be included in this proposal. Instead, it is proposed that if it should become necessary to excavate any site that will be adversely impacted by preconstruction studies, the cost of additional personnel and equipment will be covered on a cost reimbursable basis.

STEP III -- INTENSIVE SURVEY

Step III consists of intensive testing of sites located during the reconnaissance survey (Step II) of the project. Grids will be established at each site and a sampling scheme applied for testing. Each square selected for test excavation will be systematically excavated and all artifacts and features recorded, using standard archeological field methods. Site maps and soil profiles will also be prepared. Photographs will be taken to document artifacts and features in situ as well as to document the site and its location. Site limits will be delineated and data will be recovered for analysis and evaluation. Based on the analysis of this material, National Register criteria will be applied to see if the site is eligible for inclusion in the National Register of

Historic Places as specified in the federal regulations that apply to this project.

Intensive testing will also provide the means for evaluating the effects of the preconstruction and construction phases of the Susitna Hydropower Project on cultural resources. Each site will be evaluated and recommendations as to mitigating measures will be made and incorporated into the final report. Field crews, teams consisting of three archeologists, will focus Step III efforts on the dam sites, impoundment areas, access roads, staging areas, camps, borrow pits, and other potential ground disturbance areas.

STEP IV -- ANALYSIS AND REPORT PREPARATION

This step is an integral part of each step of the project. It entails compilation of the individual reports for the other steps of the project as well as synthesizes all data recovered and makes appropriate recommendations for mitigation, if necessary. Step IV is specifically aimed at the final analysis of the project in terms of sites located and documented during the other steps. The final report will include the location, description, and a mitigation recommendation for each site reported during Steps I, II, and III. Step IV will include mitigation recommendations, if necessary , for the sites located, and an estimated budget for any archeological excavation that must be done prior to the start of actual construction of the Hydropower Project as specified by federal and state regulations. The overall effectiveness of the research design, field procedures, and analysis will be discussed. A full-scale report, including sections on the vegetation, fauna, geology, history, prehistory, and native populations will be part of the report.

As presently scheduled, the FERC license application will be prepared prior to completion of the final cultural resources report. The cultural resources section of the exhibit will therefore be based on the two annual interim reports. This will include recommendations on as many sites as possible. Certain critical information, such as radio-carbon determinations of samples collected during 1981, as well as recommendations on other sites, will be submitted to FERC in the first supplementary environmental report.

STEP V -- CURATION OF RECOVERED COLLECTIONS AND SUPPORTING DOCUMENTATION

Curation of recovered artifactual material and associated contextual data will be an ongoing program throughout the duration of the project. With the University of Alaska Museum performing the archeological investigations, there will be no packaging and shipping costs to the designated repository or necessity to inventory the incoming collection. All recovered material and supporting documentation will be housed at the University of Alaska Museum and curated in accordance with state and federal requirements pertinent to the preservation of antiquities.

SECTION 6: FORMULATION OF RESEARCH AND SAMPLING DESIGNS

RESEARCH DESIGN

The University of Alaska Museum will develop a research design that will guide this research project and focus reconnaissance and intensive survey toward specific areas that are slated for subsurface disturbance. Research designs for field studies, such as the Susitna Hydropower Project, must be carefully formulated in order that research questions and management interests are taken into account (Schiffer and Gumerman 1977). The purpose of the research design is to explicate the methods and techniques for acquiring and analyzing existing data and to predict the expected outcome of the analysis (Goodyear et al. 1978). As a result, research efficiency is improved by producing criteria for determining the relevance of data and by evaluating criteria for assessing the adequacy of inferences drawn from the data (Goodyear et al. 1978).

The research design will be carefully developed for this project and will incorporate the following elements (modified from McGimsey and Davis 1977:72-73):

1. Basis of archeological and anthropological perspective governing research (theoretical basis).

2. Environmental, archeological, ethnographic, and ethnohistoric contents of the area (literature search).

3. Research goals and rationale (project parameters).

4. Research strategy including sampling method, sample size, rationale for selection of sampling areas, data recovery techniques, analysis procedures, and dissemination of research results (field methods and data manipulation).

The research design will be developed during Step I of this project. It will then guide the 1980 and subsequent field programs. Flexibility will be incorporated into the research design to meet effectively the archeological and engineering needs during this multi-year project.

SAMPLING DESIGN

In an archeological project that includes reconnaissance, intensive survey, and excavation, it is necessary to develop a sampling design that takes the needs of each phase into consideration. For the reconnaissance level survey (Step II) it is necessary to develop a means of obtaining representative and reliable data based on research conducted in a limited but selected portion of the study area. Valid probability statements can then be extrapolated from the data collected to other parts of the study.

More intensive survey aimed at providing site specific information (Step III) will require more thorough sampling aimed at determining the size and nature of specific sites. Step III sampling will be

implemented for all sites located in areas where preconstruction and/or dam construction has the potential of causing an adverse impact on cultural resources. As certain activities during the preconstruction and construction phases of the Susitna Hydropower Project have been identified as causing surface or subsurface disturbance (see section entitled Step II), both state and federal regulations mandate that all historic and archeological sites be inventoried, effects of the project on each site be determined, and any adverse impact mitigated before these projects can proceed. If the appropriate mitigating measure is excavation, it is possible that a third sampling scheme will be necessary if the entire site cannot be excavated.

Although it may be necessary to develop three separate sampling schemes for each of the above steps, it is possible at this stage to examine features that would be applicable to all of them. A number of sampling schemes are available for studies of this type. A basic approach is simple random sampling, where units are chosen at random from the sampling universe. While usually the easiest approach, it is generally the least precise if any a priori data are available about site distributions in the study area (Read 1975). Also, archeological research has shown that sites are not randomly distributed on the landscape. Random sampling also presents the possible drawback that units selected could (and often do) fall within a very localized section of the study area. Furthermore, one of the main criteria for simple random sampling is that all units must be accessible. Because of the topography of the study area, some areas have difficult access. Such difficult sampling locales often escalate costs and reduce efficiency. The sampling scheme that is most amenable to an archeological project of this type is stratified sampling.

Stratified sampling is best suited for the study area because it allows the integration of archeological data with historic, ethnographic, geological, and ecological information to influence the selection of survey locales. This is very essential to Step II studies, but must be meshed with project constraints that identify areas which will be disturbed due to preconstruction or construction related activities which prioritize locales within the study area. Experiments show that stratified sampling is an accepted population predictor (Mueller 1974). In stratified sampling the research unit is subdivided on the basis of some prior knowledge (be it scientific or project oriented) into sampling units.

Sampling units will be based on certain criteria. These include but are not limited to: (1) temporal units based on current knowledge of the cultural chronology of interior Alaska, (2) the known distribution of archeological site locations for specific time periods, (3) site locational information gleaned from ethnographic and historic literature, (4) temporally identified geologic units which establish maximum and minimum limiting dates for human occupation and land use within specific geographic locales, (5) geological processes, and (6) an analysis of topography and ecology (past and present) of the study area. Areas for survey can then

be ranked and those areas exhibiting the highest archeological potential in locales slated for immediate subsurface disturbance can be given highest priority for survey, and mitigation if necessary.

KEY PERSONNEL

PRINCIPAL INVESTIGATOR (PI)

The PI bears overall responsibility for the project including research design, obtaining necessary permits, scheduling, crew selection, prefield training, quality assurance, communication with other professionals, data collection and analysis, report preparation and editing, and curation of artifacts. He will have overall responsibility for seeing that the project complies with proposed scheduling, budgeting and all state and federal regulations that apply to cultural resource management. It is expected that due to administrative responsibilities the PI will not be available for long periods in the field during this portion of the project. In this case, the PI will delegate responsibilities to the Project Supervisor.

The PI for this project will be Dr. E. James Dixon, Jr. (Ph.D., Brown University, 1979). Dr. Dixon is Curator of Archeology and Assistant Professor at the University of Alaska Museum, Fairbanks, and has over 12 years of archeological experience in the state. He is a member in good standing of the Society of Professional Archeologists (SOPA) and meets all the requirements for membership in this organization. Dr. Dixon has published numerous articles on Alaskan archeology and anthropology, has administered several large archeological contracts, and has prepared comprehensive reports for them. Dr. Dixon possesses the necessary archeology background and administrative experience to fulfill the requirements of this project.

PROJECT SUPERVISOR (PS)

The Project Supervisor (PS) will have responsibility for directly supervising all phases of the field work and analysis. He will collaborate in designing the research, sampling strategy, and personnel hiring, and will implement programs in the field. Initial preparation of all reports will be the responsibility of the PS. The PS will direct all field crews and act on behalf of the PI in dealing with other project personnel. He will be responsible for all field equipment and supplies and will direct field logistics. He will also be responsible for quality assurance and safety in the field. It will be the responsibiltiy of the PS to see that all data necessary for completion of the archeological section of the Susitna Hydropower Proejct are collected in a manner which meets professional standards.

The PS for this project will be Mr. George S. Smith (M.A., University of Alaska, 1978). Mr. Smith is a Research Associate in Archeology, having been PI and PS on a number of large archeological projects in remote coastal and interior areas of Alaska. He is experienced and competent in research design, sampling strategy, personnel management, supply, field logistics, data collection,

analysis, and report preparation. He is also one of the leading experts on zooarcheology in the state.

BIBLIOGRAPHY

Alaska, Department of Natural Resources

1977 Resources Bibliography, Susitna River Basin. State of Alaska Department of Natural Resources, Planning and Research Section, Anchorage.

Alaska, Office of History and Archeology

1973 Alaska Heritage Resource Survey Index. Alaska Division of Parks, Department of Natural Resources, Anchorage.

Alaska District, Corps of Engineers

1978 Plan of Study for Susitna Hydropower Feasibility Analysis, Anchorage.

Anderson, D.D.

1968a A Stone Age Campsite at the Gateway to America. Scientific American 218(6):24-33.

1968b Early Notched Points and Related Assemblages in the Western American Arctic. Manuscript on file, University of Alaska Museum, 33 p.

Bacon, G.

1975 Heritage Resources Along the Upper Susitna River. Miscellaneous Publications History and Archeology, Series No. 14, Alaska Division of Parks, Anchorage.

1978 Archeology in the Upper Susitna River Basin. Report to the Alaska District, Corps of Engineers. Contract Number DACQ 85-78-0017. Manuscript on file, University of Alaska Museum.

Cook, J.P. and R.A. McKennan

The Village Site at Healy Lake, Alaska. An Interim Report. Paper presented at the 35th Annual Meeting of the Society for American Archeology, Mexico City.

Dixon, E.J., Jr. and D.C. Plasket

1978 Archeological Survey and Testing of Cave Deposits Along the Porcupine River, Alaska. Proposal submitted to the National Geographic Society. Manuscript on file, University of Alaska Museum.

Dixon, E. J., Jr., G.S. Smith and D.C. Plasket

1979 Fort Wainwright Archeological Reconnaissance Research Strategy. Manuscript on file, Univerity of Alaska Museum.

deLaguna, F.

1975 The Archeology of Cook Inlet, Alaska. Second Edition. Alaska Historical Society, Anchorage.

Dumond, D.E.
1978 The Eskimos and Aleuts. Thames and Hudson, London.

Goodyear, A.C., L.M. Raab and T.C. Klinger
1978 The 'Status' of Archeological Research Design in Cultural Resource Management. American Antiquity 43(2):159-173.

Hoeffecker, J.F.
1978 The North Alaska Range Early Man Project. A Report to the National Geographic Society and the National Park Service on the Potential of the North Alaska Range for Archeological Sites of Pleistocene Age. Manuscript on file, University of Alaska Museum.

Holmes, C.E.
1975 A Northern Athapaskan Environment System in Diachronic Perspective. Western Canadian Journal of Anthropology 5(3-4):92-124.

Irving, W.N.
1957 An Archaeological Survey of the Susitna Valley. Anthropological Papers of the University of Alaska 6(1).

1978 Pleistocene Archeology in Eastern Beringia. In Early Man in America, Occasional Paper No. 1, Department of Anthropology, University of Alberta, Edmonton, pp. 96-101.

Krauss, M.E.
1973 Na-Dene. Current Trends in Linguistics 10(1):903-978.

McGimsey, C.R. and H.A. Davis
1977 The Management of Archeological Resources. The Airlie Hoch Report Special Publication of the Society for American Archeology.

Morlan, R.E.
1978 Early Man in Northern Yukon Territory: Perspectives as of 1977. In Early Man in America, Occasional Papers No. 1, Department of Anthropology, University of Alberta, Edmonton. pp 78-95.

Mueller, J.W. (editor)
1975 Sampling in Archaeology. Univeristy of Arizona Press, Tucson.

Read, R.W.
1975 Regional Sampling. In Sampling in Archaeology, ed. by J.W. Mueller. University of Arizona Press, Tucson.

Reger, D.R,
1978 1977 Excavations on the Beluga Point Site. Paper presented at the 5th Annual Anthropology Association Conference, March 17-18, Anchorage.

Schiffer, M.B. and G.J. Gumerman (editors)
1977 Conservation Archeology: A Guide for Cultural Resource Management Studies. Academic Press, New York.

Schwager, C.L.
n.d. Notes on the Paleoecology of the Northern Archaic Tradition. Manuscript on file, University of Alaska Museum, 11 pp.

U.S. Bureau of Reclamation
1952 Susitna River Basin: A report on the potential development of water resources in the Susitna River Basin of Alaska.

West, F.L.
1967 The Donnelly Ridge Site and the Definition of an Early Core and Blade Complex in Central Alaska. American Antiquity 32(3):350-382.

1973 Old World Affinities of Archeological Complexes from Tangle Lakes, Central Alaska. Manuscript of paper read at the International Conference on the Bering Land Bridge and Its Role for the History of Holarctic Floras and Faunas in the Late Cenozoic. Khabarovsk.

Workman, W.B.
1977 New Data on the Radiocarbon Chronology of the Kachemak Bay Sequence. Anthropological Papers of the University of Alaska 18(2):31-36.

SUBTASK 7.07
LAND USE ANALYSIS

INTRODUCTION

An assessment of the effects of particular land uses on a specific environmental setting is not a simple one-for-one relationship. When one disrupts an essentially pristine environment to develop a modern hydroelectric project, such as the one proposed for the upper Susitna River basin, many environmental disruptions can occur. Some of these disruptions are easily predictable. However, others may occur which are not as predictable because there are few, or no previous experiences, on which the experts can rely. One then begins to rely on theoretical models, integration techniques, and other technological thought to give a "best judgement" as to what might take place if certain proposed actions (dam building, transmission lines, roads, etc.) are implemented (Cooley 1967). Land use analysis is one way of obtaining an overview of the systematic effects of a proposed development; the specific details of the project are then filled in by the specialists on the team (Davis 1976). This land use analysis will evaluate the effects of the proposed project and will provide the basis for an integral part of the Exhibit E to be submitted to FERC, as well as the supplementary environmental reports.

APPROACH

The approach is basically a comparision of land use trends to determine the major effects the project will have on the future land use of the area, and employs a modification of the McHarg Overlay Technique (McHarg 1969). The historical land use trends will be analyzed, the present land use of the project area will be examined, and an attempt will be made to isolate the factors and management decisions that have resulted in the land use that exists. The future land use of the area without the project will be predicted on the basis of interviews with land owners, land managers and resource agencies, and a consideration of the resource potentials and limitations. Unique and significant scenic and natural features of the area will be identified for consideration during the impact analysis. The projections of the changes that will result from the project will be made as a result of the collective "best judgement" of the research team.

DISCUSSION

Dr. Alan Jubenville will serve as the Principal Investigator for this subtask. He will be responsible for the development of the study plan, agency coordination, analysis of results, and assessment of land use changes caused by the proposed project. In addition to his expertise in recreation planning, Dr. Jubenville is eminently qualified to undertake this analysis.

This land use analysis will evaluate present and future land use trends to predict the land use changes that would occur in the study area as a result of the development of the proposed project, and will evaluate the significance of these changes. The steps that will be included in this evaluation follow.

The first step in the land use analysis will be the identification of the project area boundaries. These boundaries will include adjacent lands that will be affected or influenced by the project, as well as access roads and transmission corridors when the routes for these facilities have been identified. The downstream effects will also be considered in the overall land use analysis. The boundaries will be refined as updated and more detailed information is made available.

An understanding of the historical land use trends is necessary to isolate the factors and management decisions that have resulted in the present land use patterns. This understanding will be developed through a review of the University Archives materials, additional published sources, and interviews with agency and native leaders. All important leads that are obtained will be followed up. In this type of situation, it is difficult to determine which information is important until each item has been thoroughly researched. Thus, while the past trends in land use are relatively stable, and may not show the dynamic changes typical of, say, the California coast, cyclic changes certainly have taken place.

A complete description of the present land use will be developed. A base map and photo file will be developed along with a narrative description. The present land use will be described in terms of land ownership and the extent of present uses such as forest land, recreation, wildlife, developed uses, etc. As much as possible, this description will include a discussion of the planning efforts and management decisions that have resulted in the present utilization of the land.

To predict the future land use without the project, area lands will be evaluated in terms of resource potentials and limitations for alternative uses. This evaluation will be accomplished in relation to other expected changes that are predicted to occur within the area; such as, changes in land ownership, access, etc. The major landowners and land managers will be interviewed to discuss their future plans for the area. The anticipated changes that are predicted by the landowners and managers, as well as other agencies, will provide insight into the most probable future of the land.

Since the area is essentially untouched by man, it is extremely important to identify unique scenic and natural areas so that they can be considered in the assessment of impacts caused by the project. Base map and aerial photo surveys will be done based on known or suspected scenic/unique natural features. Those features that pass an initial screening will be reviewed on site to describe the feature, its significance, and the total area involved.

The significant land uses that have been identified during the previous steps will be examined during field reconnaissance visits to the area. Particular attention will be given to the land areas that have been significantly influenced by white man. The intent is to determine what lasting effects particular local changes in the landscape (such as a mining operation, logging, community development, etc.) have had on the environmental setting. This, coupled with data collected by project specialists, will aid in the assessment of overall impacts. All field data will be collected using standarized forms.

The above steps will result in a description of the present land use, a description of the most probable future land use of the area without the proposed project and an identification of unique scenic/ natural areas. In this step all the data that has been generated will be assimilated and a "best judgement" of the impacts will be projected. The changes that will be attributable to the project in the future, and the significance of these changes, cannot be evaluated without consideration of the changes that would occur without the project. The evaluation process is illustrated below:

1. Proposition A (Change from present land use)

	Area land use with project
(minus)	Area land use without project
(equals)	Overall change caused by project

2. Proposition B (Future land use without project)

	Future land use (based on long-term trends)
(minus)	Present land use
(equals)	Future change without project

3. Proposition C (The real change caused by project)

	Overall change caused by project
(minus)	Future change without project
(equals)	Actual change caused by project

Once the impacts are identified, the magnitude, duration and significance of the impacts will be evaluated and discussed. The impacts will be assessed for both the construction and operation phases of the project. A discussion of measures that could be used to mitigate the adverse effects will also be provided.

LITERATURE CITED

Cooley, R. A. 1967. Alaska: A Challenge in Conservation, Madison: University of Wisconsin Press.

Davis, D. P. 1976. Land Use, New York: McGraw-Hill.

McHarg, I. L. 1969. Design With Nature, Garden City, N.Y. The Natural History Press.

SUBTASK 7.08
RECREATION PLANS

INTRODUCTION

There may be some controversy generated by the proposed Susitna Hydroelectric Project, but few people know the area intimately and can speak with authority on the potentials or limitations of the area for other uses. It is relatively isolated yet close to the greater Anchorage area (nearly 60% of the state's population) and only 3/4 of a day's driving time from Fairbanks. When considering hydroelectric development, other uses of the area must also be considered to maximize the potentials of the area.

This subtask offers a mechanism for providing recreational opportunities at the proposed project. This will be an important element in the evaluation of the project since the recreational use of the area will affect many of the environmental impacts associated with the project, including socio-economics, fisheries, wildlife, and land use. The level of recreational development and the use generated by the provision of public facilities will be important considerations in the determination of these impacts.

Most recreation planning decisions relate to the development of access to the area; consequently, the access road, types of facilities, and level of development are critical decisions in encouraging specific types of recreational opportunities and levels of development. This proposal is based on the theorem that recreation planning, while controlling development and minimizing impacts, is done for a more important reason - controlling the experience norms to be offered. As stated by Christiansen (1977, p. 23), "This requires a comparable control to the established norm for all the supportive services - maintenance, supervision, programming, safety, security, operations, ... - necessary to sustain the predetermined (recreational experience) norm."

OBJECTIVE

The objective is to prepare a detailed plan that will optimize public recreational use of the project lands and water, in a manner that will:

(1) provide the activities and levels of development that will maximize the quality of the recreation experience;

(2) balance the development of facilities with the carrying capacity of the natural resources to minimize impacts;

(3) be consistent with planning guidelines and objectives of the managing agencies; and

(4) maximize compatibility with the proposed operation of the project and other public uses of the land.

APPROACH

The basic approach is to develop a master area plan based on the perceptions of the public, the limitations of the resource, and the planning guidelines of the managing agencies. The planning effort can be divided into a series of steps: (1) literature review (complete review of pertinent periodicals and texts, and agency publications relating to Alaska, including the Statewide Comprehensive Outdoor Recreational Plan), (2) mail questionnaire (on the perception of Alaskans to varying levels of development), (3) field assessment of resource potential for recreational use (using the Criteria for Evaluating Quality of Recreation Lands, presented in Addendum B), (4) development and evaluation of concept plans (to meet specific objectives) (Footnote 1), (5) selection of master area plan, and (6) final review and publishing of report (all affected agencies will be given an opportunity to respond). An overview of the process is shown in Exhibit 1.

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1. For a discussion on concept plans, see Christansen, M. 1977. Park Planning Handbook. New York: John Wiley & Sons, Inc. p. 44-53.

Exhibit 1: Synopsis of Recreation Plan Proposed

Step I: Literature Review

a. Reservoir planning and management.
b. River recreation.
c. Area planning guidelines.
d. Alaska documents (recreational use).
e. Susitna Valley references (popular and technical).

Step II: Mail Questionnaire

a. 2,000 Greater Anchorage and Fairbanks residents.
b. Measure perceptions of experience norms, and aggregate participation relative to these norms (Addendum A).
c. Measure perceptions of desired management and visitor service levels.

Step III: Assessment of Resource Potential for Recreation

a. Zone the Project area, for activities appropriate to the general resource capability, level of access, and anticipated management problems, such as natural hazards (Jubenville 1976, p. 225).
b. Assess resource suitability for specific activities within these zones, using the Criteria for Evaluating Quality of Recreation Lands developed by Region 9, U.S. Forest Service (Addendum B).
c. Detailed feasibility studies of the better sites identified in III. b.
d. Rank-ordering of potential sites for specific activities.

Step IV: Concept Plan

a. Design goals and objectives
b. Develop concept plans to meet the goals and objectives and related criteria.

Step V: Master Area Plan

a. Evaluate concept plans.
b. Select the best concept.
c. Develop needed support facilities.
d. Assess level of agency management.

Step VI: Final Review and Publishing

a. Jury the final results.
b. Adjust and publish plan.

SCOPE OF WORK

LITERATURE REVIEW

An extensive literature review will be conducted to identify and make use of existing pertinent information and data. This literature search will include a complete review of the appropriate periodicals and texts, as well as agency publications related to Alaska, including the Statewide Comprehensive Outdoor Recreation Plan. The review will examine the existing literature on reservoir planning in relation to recreation, river recreation, supply-demand modeling, systematic approaches to recreation program planning, and agency publications on participation patterns, changing socioeconomic factors, and user perceptions of specific recreational experiences.

PROJECTION OF RECREATIONAL USE

It will be necessary to predict the initial and future recreational use that can be expected to occur at the facilities that are provided as a part of this project. Forecasting is at best a hazardous enterprise, but predicting the levels of participation in various recreational activities is an essential ingredient in recreational planning. The types and numbers of facilities to be provided and the appropriate level of management cannot be determined without an estimate of predicted use.

The projections of participation are made more difficult in this case by the size of the area, the limitation of similar opportunities within the region, and minimal past use data. The uniqueness of the area and lack of available data preclude the use of many methods of projecting participation and suggests the use of the "judgement" method (Clawson and Knetsch 1966). To predict initial and future use of the facilities, all available data related to historical, present, and projected use trends will be analyzed. Indicators and basic causal factors, such as trends in population, income, leisure and mobility, will be evaluated. The prime potential market areas of Anchorage, and secondarily, Fairbanks will be given particular consideration.

QUESTIONNAIRE

A mail questionnaire will be sent to 2000 Anchorage-Fairbanks residents to assess their perceptions of the appropriate levels of recreational development at the proposed reservoirs and their willingness to participate at those levels of development. The questionnaire will be designed to determine the combination of access and facilities (based on descriptions) that people would respond to best, in terms of indicating a willingness to participate. This will provide an aggregate estimation of participation, in various activities, based on varying levels of recreational development. This will also give an indication of how to maximize total recreational use, realizing that the optimum solution is balancing this use with the capability of the resource to sustain such use over time.

The Principal Investigator has designed and successfully utilized similar questionnaires in the past. However, realizing the importance of the questionnaire, the design of the questionnaire will be critically reviewed and be pretested prior to distribution. Dr. Michael Chubb, a noted researcher and planner on water-based recreation projects, will critique the questionnaire design, as well as assist in the concept plan selection.

The number of questionnaires to be distributed was determined, based on a desired level of accuracy and an assumed rate of response. The mailing will be divided between Anchorage and Fairbanks in proportion to population. One follow-up is planned and a second will be used if necessary. Since Fairbanks will be receiving fewer questionnaires, an additional mailing may be required if the desired number of responses is not received after the follow-ups.

ASSESSMENT OF RESOURCE POTENTIAL FOR RECREATION

The potential of a given parcel of land for recreational use is directly related to the benefits that people can derive from using it. The potentials are determined not only by the setting and natural attributes of the site, but also by the capability of the site to withstand use. Both of these considerations will be used in the evaluation of the potentials.

An initial evaluation of the project area will be completed in the lab, using vertical aerial photography to isolate suitable areas and potential sites. The project lands will be evaluated on the basis of the general resource capabilities, levels of access, and anticipated management problems such as natural hazards (Jubenville 1976). This initial evaluation will determine the zones that have the greatest potential for development. Selected potential sites, visitor attractions and related management concerns will be located on a base map and evaluated during an initial field reconnaissance. The summer field seasons will be spent assessing the potential for providing specific opportunities both water and land-based, and the inherent limitations of the sites. Standardized criteria will be utilized to eliminate personal bias in the field site evaluation process. The standardized criteria will be based upon evaluation criteria that were developed by the U.S. Forest Service (Region 9), but will be modified to more appropriately fit this particular situation. (A summary of the criteria developed by Region 9 U.S. Forest Service has been included in Addendum B). Those sites that are identified as having the greatest potential will be further evaluated in the field to determine their feasibility in terms of providing specific experiences, site durability, safety hazards and related impacts. The final result of the assessment of resource potential will be a rank-ordering of the potential sites for specific activities.

CONCEPT PLANS

Prior to the formation of the concept plans, the information that has been gathered and generated during the planning process (including information from other disciplines) will be evaluated and

synthesized to establish the program goals and objectives. This will include participation rates, user perceptions, agency goals (Federal, State, and local), key values (attractors), etc. Once the program objectives (activities, experience levels, and necessary site and facility development) are established, three distinctly different concept plans will be developed that at least minimally meet those objectives. These concept plans will then be evaluated and a Master Area Plan will be developed.

MASTER AREA PLAN

The concept plans will be evaluated according to the following criteria:

(1) How well they meet program objectives.

(2) Suitability/feasibility site studies.

(3) Future management problems.

(4) Estimated cost of maintenance and operations.

(5) Impact of recreational use on other key values, e.g. soils stability, wildlife populations, etc.

(6) Compatibility with the normal maintenance and operations of the hydroelectric project and other land uses.

A trade-off table will be developed showing how each of the concept plans were rated on each criterion. After this a panel of experts (agency and consultants) will be asked to critique the evaluation of the variables. Adjustments will then be made, and the final plan will be selected that best meets the criteria (Jubenville 1976, 1978; Rutledge 1971).

The final Master Area Plan will include map(s) showing the location of the project lands and waters that will be developed for recreational uses, initially and in the future. It will identify the location, type, and number of the various recreational facilities planned, initially and in the future. The predictions of recreational use of the facilities will be discussed. The management responsibilities of the various facilities will be described and a schedule of recreational development and cost estimates will also be included.

This Master Area Plan is designed in accordance with the requirements of Exhibit R of a FERC license application, under existing guidelines. Modifications, if needed, can be made to conform with the upcoming revision of FERC requirements. The development of the plan is scheduled to begin in Phase I and to be completed in Phase II, after detailed design specifications and operational information is available.

LITERATURE CITED

Christiansen, M. L. 1977. Park Planning Handbook. New York; John Wiley and Sons.

Clawson, M., and J. L. Knetsch. 1966. Economics of Outdoor Recreation. Baltimore; Johns Hopkins Press.

Jubenville, A. 1976. Outdoor Recreation Planning. Philadelphia; W. B. Saunders.

Jubenville, A. 1978. Outdoor Recreation Management. Philadelphia; W. B. Saunders.

Rutledge, A. J. 1971. Anatomy of a Park. New York; McGraw-Hill Book Co.

Way, D. S. 1973. Terrain Analysis. Stroudsburg, PA; Dowden, Hutchinson & Ross, Inc.

ADDENDUM A

Table 2.1
Recreation experience and environmental modication norms for resource-oriented activities[a]

Experience/ Development Level	Recreation Experience Norm	Environmental Modication Norm
1 *Primitive*	Primary interest is the feeling of achievement, sense of adventure and challenge to the elements. Small group participation develops comaraderie. Fine opportunities for solitude. Some activities may require a high level of outdoor skills at this level. Outside distractions or influences often very displeasing.	Natural primitive environment is dominant. Minimum site modification. Rustic rudimentary improvements designed for protection of the site rather than comfort of the users. Use of indigenous materials preferred. Water provided by participant. Sanitation provisions spartan. Site maintenance by participants. Minimum controls are subtle. No obvious means of regimentation. Spacing informal and extended to minimize contacts with others. Motorized access not provided or permitted.
2 *Secondary Primitive*	Feeling of accomplishment is important but physical stamina is not essential. Several small groups may socialize briefly, then separate for the majority of the experience. Some activities may require a moderate level of outdoor skills. Outside influences tolerated.	Natural environment is dominant. Little site modification. Rustic or rudimentary improvements designed for protection of the site rather than comfort of the users. Use of synthetic materials avoided. Water and sanitation provisions developed but simple. Site and facility maintenance provided at least seasonally. Minimum controls are subtle. Little obvious regimentation. Spacing informal and extended to minimize contacts with others. Motorized access provided or permitted. Primary access over primitive roads.

Source: Christiansen 1977.

Table 2.1 (Continued)

Experience/ Development Level	Recreation Experience Norm	Environmental Modification Norm
3 *Intermediate*	A taste of adventure is important, but a sense of security is present. Considerations for convenience and comfort accepted. Some activities may require a moderate level of outdoor skills. Outside influences accepted.	Environment essentially natural. Site modification moderate. Facilities about equally for protection of site and comfort of users. Design of improvements is usually based on use of native materials with contemporary conservation techniques. Water and sanitation provisions adequate and regularly maintained. Inconspicuous vehicular traffic controls usually provided. Roads may be hard surfaced and trails formalized. Primary access to site may be over high standard well traveled roads. Visitor information services, if available is informal and incidental. Security patrols may be made periodically.
4 *Secondary Modern*	Experience provides change of routine and surroundings. Apparent opportunities for socializing with others. Provisions for convenience and comfort expected. Willing to pay for extras. May rely on program services for entertainment as much as exposure to the environment. Outside influences present but not regarded as incongruous.	Environment pleasing but necessarily natural. Site heavily modified. Some facilities designed strictly for comfort and convenience of users but luxury facilities not provided. Facility designs may tend toward and incorporate synthetic materials. Extensive use of artificial surfacing of roads and trails. Vehicular traffic controls present and usually obvious. Primary access usually over paved roads.

Table 2.1 (Continued)

Experience/ Development Level	Recreation Experience Norm	Environmental Modification Norm
		Plant materials usually native. Visitor information services frequently available. Maintenance and security checks regular and periodic. Some programming services provided.
5 *Modern*	Pleasing environment attractive to the tourist, the novice or highly gregarious recreationist. Opportunity to socialize with others very important. Satisfies need for compensation experiences. Obvious to user that he is in secure situation where ample provision is made for his personal comfort. Expects to be entertained by program services; does not expect to find own amusement. Outside influences considered part of the show.	High degree of site modication. Facilities mostly designed for comfort and convenience of users include flush toilets; may include showers, bath houses, laundry facilities, and electrical hookups. Synthetic materials commonly used. Formal walks or surfaced trails. Regimentation of users is obvious. Access usually by high speed highways. Plant materials may be foreign to the environment. Formal visitor information services usually available. Designs formalized and architecture may be contemporary. Mowed lawns and clipped shrubs not unusual. Maintenance and security forces usually visible. High degree of programming services.

[a] Adapted from "Recreation Experience Levels" from U.S. Department of Agriculture, *Forest Service Manual*, 2330.5-3 and "National Forest Camp and Picnic Site Levels of Environmental Modification and Recreation Experiences" from *Forest Service Manual*, 2331.11c-3.

ADDENDUM B

SELECTION D

CRITERIA FOR EVALUATING QUALITY OF RECREATION LANDS*

Occupancy and Observation Sites

A. *Attraction.* Water attractions will include lakes, impoundments, major streams, cascades, and scenic rapids. Slow sluggish streams and small springs would be considered poor attractions. Land features would include unusual scenic views, outstanding timber stands or groves, historical areas, archeological areas, geological areas such as caves and rock formations, botanical areas with rare plant life, or zoological areas having unusual animal life. In some cases the attraction will be a combination of both land and water features.

The attraction must be within reasonable distance of the potential site. Usually this will mean about 700 feet for occupancy sites exclusive of waterfront or buffer zones. On those forests where suitable national forest land under the above specification will not be available to meet the projected demand, it will be necessary to consider lands up to one half mile or more from an attraction. Certain sites might be very attractive which may serve as a base from which fishing, swimming, or boating can be enjoyed on one or more nearby lakes or streams. Opportunity to hike along trails to observe some interesting scenery, or to enjoy historical, geological or other features, would enhance the attractiveness of such sites.

Both water and land features on a combined scale will be used for rating the attraction. The area limitations of 10 acres more or less for a lake

*Developed by Region 9, U. S. Forest Service.

Source: Jubenville 1976, pp. 351-365.

or reservoir shown on U. S. Forest Service Form 17, will not be a factor in this region. As a guide for our purposes, the water attractions should be rated as follows:

Lake or reservoir, two or more recreational uses such as swimming, fishing, and boating possible.	1
Fast flowing rivers and other major nonpolluted streams.	2
Waterfalls, cascades, sizable springs, or small live streams.	3
Slow moving rivers, reservoirs, and lakes which because of size, heavy weed growth, or shallow waters are suitable only for fishing and/or waterfowl hunting.	4
Bog lakes, polluted rivers, and streams which can be made productive.	5
As on Form 17.	6

The rating items for land features shown under A–2 will be used as listed. Examples of unusual scenery might include areas along the Great Lakes, views overlooking several lakes, or scenic stretches of rivers. Examples of other outstanding features might include certain historical sites such as the Bay Furnace, old forts, trading posts, etc; archeological areas such as painted rocks, Indian mounds, and exceptional big game, bird, or waterfowl hunting areas. Parks or meadows in the second item are confined to the West. Here we will consider exceptional groves or timber stands, and other pleasing views, vistas, or features that are uncommon but not necessarily outstanding. On a combined rating scale the minimum acceptable attraction would have a rating of *8*. Quality prescriptions would be as follows:

		Minimum Acceptable Conditions
Fair attraction	7–8	Slow rivers and lakes suitable only for fishing or waterfowl hunting w/o scenic land features, or bog lakes, polluted streams w/common scenery.
Good atttraction	5–6	Waterfalls, cascades, small scenic streams w/common scenery. Fast flowing major stream w/o scenic features.
Outstanding attraction	1–4	Lake or reservoir suitable for 2 recreation uses w/common scenery, or unusual scenery w/small live stream or cascades.

B. *Climatic Relief.* Most of the forest areas of the region have an agreeable climate during the summer season, more so than nearby population centers. These areas, therefore, afford a good degree of climatic relief.

The ratings as shown on the work plan and on U.S. Forest Service Form 17 will be used. The minimum acceptable rating for this criterion will be a *4*. Quality prescriptions will be as follows:

		Minimum Acceptable Conditions
Fair	4	0–5°
Good	3	6–10°
Outstanding	1–2	11–15°

C. *Forest Environment.* Environment means the general surroundings

and "atmosphere" of the site. It is affected by physical conditions in and around it. Environment is not measurable in precise terms, but it can be expressed in relative terms. The order of desirability as shown on the inventory Form 17 will be used. Interpretation will depend upon the skill of the examiner.

To assist in rating this criterion, a hypothetical set of conditions are presented here:

Grade 1 The site is relatively undisturbed, the timber is fairly uniform in character, mostly of large poles to saw timber size, not necessarily a closed stand. Very little evidence of recent logging present. The site is not within sight and sound of a noisy highway, nearby commercial enterprise such as a gas station, resort, tavern or farm. Very little erosion evident. Wildlife species varied but not necessarily abundant.

Grade 2 The timber stand would be generally similar to above. Minor detractions might include proximity to a main highway with fairly heavy traffic the noise of which is audible, or evidence of last logging job present in the form of small scattered and half rotted tops on the ground, or a group of summer homes is present near by.

Grade 3 The timber is scattered or patchy or a very young age class. Some evidence of recent partial cut is present. Crop, land pasture, or private development bound one side of the site.

Grade 4 Serious detractions might include: the surrounding area has just been subjected to a heavy cut of timber with a poorly stocked residual stand, or the site is small and is surrounded by crop land, pasture, or other private development, or the site is open and without cover but is otherwise suitable.

Grade 5 In this class would be included areas that in their present state are not acceptable for recreation use, but with correction of the conditions would be. Examples of such situations might include sites that are low, poorly drained, shallow swamp areas which can be made usable by drainage or filling; sites where most of the ground area is covered with poison ivy; or sites subject to sand blows, which can be stabilized by establishment of ground cover.

Grade 6 An example of an unacceptable area would be one that is subject to flooding due to frequent fluctuation of water levels during the use season and where correction of the situation is not possible.

The minimum acceptable rating for this criterion will be 5. Quality prescriptions will be as follows:

		Minimum Acceptable Conditions
Fair	4–5	Unacceptable but correction feasible.
Good	3	Detractions substantial.
Outstanding	1–2	Well preserved w/minor detractions.

D. *Terrain.* Picnicking probably is the least demanding occupancy use insofar as terrain is concerned. In many cases the terrain can be modified to make it usable for occupancy use. It is considered that slopes of over 30% are generally unsuitable for occupancy development.

Terrain usually will not be a limiting factor in rating observation sites, as many of these sites will be small, involving only minor developments, and may be accessible only by foot trail. However, terrain is an important factor where parking, picnic, and sanitary facilities will be necessary in

connection with observation sites. This criterion should be rated for observation sites in the same manner as for occupancy use.

The minimum acceptable rating will be *3*. Quality prescriptions will be as follows:

		Minimum Acceptable Conditions
Fair	3	20–30% slope.
Good	2	10–20% slope.
Outstanding	1	0–10% slope.

E. *Soil. Fertility*—this term is intended to express the relative difficulty of establishing or retaining the vegetative cover. The type of soil, aspect, and topography all have an influence on fertility. For the purpose of this survey, the following classification of fertility has been made:

Good Medium to well drained silts, sandy clay and clay loams, heavy clay and muck soils.

Fair Gravelly and sandy loams, moist but well drained sands.

Poor Dry sands, gravels, rock, and eroded soils.

Stability—this term means the resistance of the soil to damage by erosion or compaction as a result of use. Steepness and length of slope, kind of soil, amount of cover are all factors that affect stability. The following conditions describe the various ratings for this term:

Good Not more than 3% slope. Length of slope not more than 100 feet. The soil is sandy clay or clay loam, heavy clay, or rock.

Fair Slope less than 3% but over 100 feet long. Slopes over 3% but not more than 10% and not over 200 feet in length. The soil is sand or gravelly loam, or heavy sand.

Poor Slopes are not over 10% but more than 200 feet long, and all slopes over 10%. The soil is silt, fine sand, or severely eroded.

Depth—the depth of soil affects the supply of water and nutrients to plants as well as the ability of the forest to withstand winds. In this part of the region the depth of soil will refer to distance to bed rock or the water table. This factor will be rated as follows:

Good Soils more than three feet deep.

Fair Soils between one and three feet deep.

Poor Less than one foot deep.

Permeability—this term in intended to express the ability of the soil to absorb or to allow water to percolate through it. The texture of the soil has a direct bearing on this capacity. The coarser the soil, the greater the permeability. For the purpose of the survey, the soils will be classed as follows:

Good Sands, gravel, gravelly or sandy loam.

Fair Stony loam, clay and silt loam.

Poor Heavy clay, or silt. Soil compacted as a result of heavy use such as logging.

Damp, poorly drained, bog or swamp—The soil would not be given this classification unless most of the site would fall into this class.

Extensive rock exposures, ledges, etc.—extensive rock exposures may make it prohibitive to develop a potential area for occupancy. Development may be limited to a small picnic area. If the potential site can be developed for $3,000.00 per development acre or less, then it can be considered as feasible. In situations such as this, give this factor an arbitrary rating of *3*.

The minimum acceptable rating for the soil criterion will be *3*. Quality prescriptions will be as follows:

		Minimum Acceptable Conditions
Fair	3	Fair fertility, stability, permeability; thin.
Good	2	Good stability; fair fertility, permeability and depth.
Outstanding	1	Good fertility, stability, permeability; fair depth.

F. *Shade or Shelter.* High shade in this criterion means shade from trees over 30 feet in height. Low shade is from trees 30 feet or less in height. When the canopy is composed of both high and low shade, rate it on the basis of that which is in greatest proportion. Seven conditions of shade are recognized in order of desirability. No rating will be done on the basis of a direct shelter or constructed basis. This is for certain western conditions.

The inventory does not provide for consideration of the composition of the canopy providing the shade. It is felt that this should receive consideration. Four sets of canopy conditions have been set up which are added to Form 17. Briefly, the conditions in order of quality are described as follows:

Thrifty mature stands of northern hardwoods, hemlock, pine types, and various mixtures of these.

Pole types would be the same as above, including paper birch, thrifty aspen, and spruce fir below small sawlog size.

Overmature hardwoods, overmature spruce fir; mature aspen. These would include the overmature, decadent, hollow, unthrifty hardwood and spruce fir stands where more than a fairly high danger exists from windfall breakage and snow damage, along with mature aspen.

Saplings and undesirable species would include young stands less than thirty feet high. Very unthrifty, overmature, and off-site aspen, open fields that are being taken over by scrub oak, cherry, aspen, etc., and open areas where planting is necessary.

Form 18 for this criterion has been amended to include the composition rating. It will be scored along with the shade factor. The minimum acceptable rating will be a *4*. The quality prescriptions will be as follows:

		Minimum Acceptable Conditions
Outstanding	1	High shade 50–100%; pole types.
Good	2	Low shade 25–50%; pole types. High shade 25–50%; overmature, aspen. High shade 10–25%; thrifty mature fir.

Fair	3-4	High and low shade less than 10% w/sapling or undesirable hardwood or open areas.

G. *Cover (Composition and Density).* The term "cover" as used here includes the vegetation below the shade producing level. It includes the grasses, shrubs, and reproduction. This type of cover serves to protect the site from erosion, provide screening, and may contribute to its general beauty. It also may have a bearing on the cost of site development and maintenance.

It is difficult to define exact conditions of composition and density of this low cover. *It means having the right amount of a desirable mixture of species that will provide enough screening between family units or on the buffer strip around the area, and still allow for adequate circulation of air.* The presence of flowering shrubs would add to the general beauty of the site. On the other hand, too dense a stand of desirable species of reproduction in the form of a thicket all over the site would be undesirable.

The following are broad guides which may be of assistance in rating this criterion:

Composition

Excellent—The reproduction may consist of any mixture of the more desirable hardwoods, hemlock, spruce and fir, or pine along with such shrubs such as dogwood, blueberry, serviceberry, snowberry, honeysuckle. Ferns and grasses may be found in the openings. Poison ivy is present in a small quantity which can be readily eradicated with herbicides.

Good—Conifers, the more desirable hardwoods, and shrubs are present in quantity, but almost 50 percent of the ground cover consists of such species as hazel, scrub oak, rose, hawthorn, or sweet fern. Poison ivy is present as above.

Fair—Desirable hardwoods and conifers scarce or absent. The cover consists of a variable mixture of scrub oak, aspen, hazel brush, buckbrush, sweet fern. Small patches of poison ivy and raspberry or blackberry may be present.

Unsatisfactory—Poison ivy, blackberry, raspberry, nettles, or prickly ash occupy most of the site in various mixtures.

Density

Excellent—At least 60 percent but not more than 80 percent of the area not occupied by overstory trees is stocked with desirable cover species. Points on the site at a distance of 100' are intervisible but not clearly so.

Good—30-60 percent of the ground area not occupied by overstory trees is stocked with a good or better composition of species. Points on the area at a distance of 100' are readily visible.

Fair—10-30 percent of the ground area not occupied by overstory trees is stocked with a fair or better composition of species. There are situations where the stocking of reproduction even of desirable species is too dense, walking over the site may be difficult, with visibility being limited to a very short distance. This is an undesirable but not entirely unsatisfactory situation which can be corrected by cutting. It is classified here.

Unsatisfactory—Less than 10 percent of the site is occupied by a fair or better composition of species.

The minimum acceptable rating for this criterion will be a *4*. Quality prescriptions are as follows:

		Minimum Acceptable Conditions
Fair	3–4	Composition and density unsatisfactory but correction feasible.
Good	2	Composition and density fair or composition excellent w/unsatisfactory density.
Excellent	1	Excellent composition—good density. Good composition—excellent density.

H. *Domestic Water.* The rating of this criterion needs no explanation. The formula in the work plan instructions which is also indicated on Form 17 (Instr. 12) is applicable to R–9 situations. An examiner of a site may not be in a good position to make this evaluation. The advice of the ranger, forest engineer, or other qualified person familiar with problems of local wells should be consulted before the costs are calculated. The best water source may not be a well but a lake, stream or nearby spring.

The minimum acceptable rating will be a *4*. Quality prescriptions are as follows:

		Minimum Acceptable Conditions
Outstanding	1	Available at low cost.
Good	2	Available at moderate cost.
Fair	3–4	Unavailable.

Accessibility

The relative accessibility of each site will be rated. This will be done independently of the physical rating. Relative accessibility is based upon the cost per development (usable) acre of providing access from the nearest existing road or road planned for construction by the year 2000 to the potential site being examined. Internal service roads within the site will not be considered here.

The following accessibility guidelines will be used in making this evaluation:

Outstanding accessibility—A site that is accessible by means of an existing road or water route, or if not accessible, the cost of construction of an access road will not be more than $1500 per development acre.

Good accessibility—A site that is not accessible and the estimated access road costs will be not more than $1500 to $2500 per development acre.

Fair accessibility—An unaccessible site to which access is considered feasible, provided road cost will be not more than $2500 to $4000 per development acre.

Unsatisfactory accessibility—Sites which do not meet the above conditions due to access road costs in excess of $4000 per development acre.

In general, in this region most of the potential sites will be within one-half mile of either the planned primary or the secondary transportation system. A SN22 road will generally be standard for providing access to rec-

reation areas. Assistance of the forest engineer should be obtained in providing estimated average road construction costs for different conditions that may be encountered on the forest.

Determination of per acre costs are derived as follows:

$$\frac{\text{road length (mi.)} \times \text{ave. construction cost/mi}}{\text{usable area}} = \text{access road cost per development acre}$$

Data concerning accessibility is recorded in the access road block on the first page of Form 17. Indicate the information as it applies to the various statements. In those situations where the site is over ½ mile away from an existing or planned road but access is feasible, modify the next to the last statement to show this. Under item (9) in the last statement, show the estimated cost per development acre.

The relative accessibility rating that is obtained will be compared with the site quality rating. The final rating will be that assigned to site quality, *unless it is higher* than the accessibility rating, in which case the latter will be the final rating.

Potential Waterfront Sites

In making evaluations of the criteria for these sites, keep in mind that both swimming and boating sites are being considered. Swimming and boating sites in most cases will be adjunct to occupancy sites. In some situations, a boating site will serve only as an access point for the launching of boats. Similarly there may be potential swimming sites suitable for development not in connection with an occupancy use.

Where the waterfront development site is part of the same area being examined for occupancy, only the 100 foot waterfront zone will be evaluated for this use. Do not consider part of the occupancy area as to suitability for bathhouse or parking purposes. In those cases where the potential waterfront sites are not in conjunction with a potential occupancy site such as involving only a swimming or a boat access site to a fishing or waterfowl lake, the land required for bathhouses and parking areas will also be evaluated.

A. *Water Temperatures.* Average water temperatures during the summer season may be a limiting factor for swimming activities in some of the waters in this part of the region. Literature on the subject of water temperature in swimming pools indicates that the average low temperature should be about 70°. Temperature insofar as a boating site is concerned is not significant. These sites will be used not only by water sports enthusiasts but by fishermen and waterfowl hunters as well.

Quality prescriptions for these two uses will be as follows:

	Swimming	*Minimum Acceptable Conditions*	*Boating*	*Minimum Acceptable Conditions*
Outstanding	1	73° + F	1–2	68–73°F
Good	2	68–73°F	3	60–67°F
Fair	3*	60–67°F	4*	less than 60°F

*Minimum acceptable rating.

B. *Shoreline or Flow Fluctuation.* This criterion is well explained in the work plan. It is especially of concern with reservoirs or impoundments that may be subject to drawdown for flood control or power purposes.

A knowledge of the type of bottom and steepness of the slope would have a bearing as to whether a fluctuation in water levels would constitute a detraction. For example, a sandy, gentle slope would still be an attractive swimming or boating site with more fluctuation than a steeper slope or one that may have clay, rocks, mud, or stumps exposed when water is drawn down. This should be kept in mind when these sites are being examined.

Quality ratings are as follows:

	Swimming	*Boating*	*Minimum Acceptable Conditions*
Outstanding	1	1	Fluctuation little or none.
Good	2	2	Fluctuation moderate or immaterial.
Fair	3*	3*	Major detractions less than ½ the season.

*Minimum acceptable rating.

C. *Shoreline—First 20' Above Water.* On this region most of the lakes do not have a clear beach of up to fifty feet. We have arbitrarily set a distance of twenty feet for consideration here as this might be closer to the average. As explained in the work plan instructions, this criterion is a measure of suitability of the site in its natural state as well as an indicator of development costs. It is recognized that developments can be made to overcome almost any deficiency.

The various elements to be rated are self-explanatory except the soil-mud item. Include here heavy soil types as well as mud. In rating this criterion, a timbered site will be defined as one that has a stocking of 50% or more of poles or larger trees. If the stocking of timber is less than 50%, it will be considered as nontimbered. A timbered site may have sandy, gravelly, or clay soil. In those situations where a timbered site is underlaid with clay, rate the site as *4*. Quality prescriptions are as follows:

	Swimming	*Minimum Acceptable Conditions*	*Boating*	*Minimum Acceptable Conditions*
Outstanding	1	Sand	1–2	Gravel
Good	2	Gravel	3	Timbered
Fair	3*	Timbered	4–5*	Rock

*Minimum acceptability.

D. *Bottom, Below Waterline to a 5' Depth.* The nature of the bottom affects the suitability of a site for boating and swimming. In rating this criterion for boating, consider the nature of the bottom to a depth of 2 to 3 feet. For swimming, rate the bottom to a wading depth of 5 feet. Quality prescriptions are as follows:

	Swimming	*Minimum Acceptable Conditions*	*Boating*	*Minimum Acceptable Conditions*
Outstanding	1	Sand	1–2	Gravel
Good	2	Gravel	3–4	Mud
Fair	3*	Rock	5*	Rock

*Minimum acceptability.

E. *Distance, Shoreline.* The requirements for this criterion as explained in the work plan are satisfactory and will fit most of the conditions in this region. It is a measure of drop-off from the water line to maximum wading depth. In those areas where canoeing is a popular sport, it may be desired to rate a potential boating site for canoeing, particularly a stream that is not suitable for all around boating. In such situations the distance to about a three-foot depth will be rated. When a site is rated with this in mind, appropriate notes should be made in the comments on Form 18. Quality prescriptions are as follows:

	Swimming		*Boating*	
100' or more	1	Outstanding	4	
50–100'	2	Good	3*	Fair
25–50'	3*	Fair	2	Good
0–25'	4		1	Outstanding

*Minimum acceptability.

F. *Industrial or Domestic Pollution.* The terms as defined in the work plan for this criterion need no further explanation and will apply in this region. Quality prescriptions are as follows:

	Swimming	*Boating*	*Minimum Acceptable Conditions*
Outstanding	1	1	Uncontaminated.
Good	2*	2	Contaminated.
Fair		3*	Light pollution.

*Minimum acceptability.

G. *Color and Turbidity.* These characteristics as defined in the work plan will apply to this part of the region. The brown "tea-colored" condition in many of the waters of the Lake States resulting from tannins in solu-

tion are not a deterrent to water activities. Quality prescriptions are as follows:

	Swimming	*Boating*	*Minimum Acceptable Conditions*
Outstanding	1	1	See U.S. Forest Service Form 18 P-26a.
Good	2*	2	See U.S. Forest Service Form 18 P-26a.
Fair		3*	See U.S. Forest Service Form 18 P-26a.
Unsatisfactory	3		

*Minimum acceptability.

H. *Wind Velocity and Constancy.* Unfavorable winds would be winds of such velocity as to create conditions on a body of water so as to make it very difficult or unsafe for the majority of small boats to stay out for the purpose of general boating, water sports, or fishing. Small boats would be generally defined as those using outboard motors common today. Swimming, on the other hand, may be enjoyed in spite of windy conditions on the lake.

It is doubtful that unfavorable wind conditions are much of a factor except in certain locations along the Great Lakes. Quality prescriptions are as follows:

	Swimming	*Boating*	*Minimum Acceptable Conditions*
Outstanding	1	1	See U.S. Forest Service Form 18 P-26a.
Good	2	2	See U.S. Forest Service Form 18 P-26a.
Fair	3-4*	2*	See U.S. Forest Service Form 18 P-26a.
Unsatisfactory		3-4	See U.S. Forest Service Form 18 P-26a.

*Minimum acceptability.

I. *Classification of Waters.* This classification is meant to show the management of the waters being considered. Various management may affect or limit developments that may be contemplated.

Navigable waters according to law are those that are navigable-in-fact. If a boat can be floated, then the waters are navigable, and they are public waters. Navigable interstate waters such as the Mississippi and Ohio Rivers and tributaries thereto are under the jurisdiction of the federal government. The agency in charge is the Corps of Engineers.

Other public waters would include impoundments under the jurisdiction of the Corps of Engineers, Bureau of Reclamation, Fish and Wildlife Service, Soil Conservation Service, states, other public agencies, as well as certain natural lakes.

National forest waters would be those impoundments constructed by the Forest Service and natural lakes entirely surrounded by national forest ownership. In these cases, the Forest Service controls the developments on these lands.

Private waters would include private impoundments and for this classification all natural lakes surrounded by private land.

On navigable and public waters usually there are no restrictions to an

abutting owner in development or use of a swimming or boating site. For our purposes in this part of the region, navigable and other public waters are equally satisfactory for these developments. Quality prescriptions for this criterion are as follows:

	Swimming and Boating	*Minimum Acceptable Conditions*
Outstanding	1–3*	Other public.
Unsatisfactory	4	Private waters.

*Minimum acceptable rating.

Winter Sports Sites

Criteria for this use are explained on pages 88–92 of the work plan. Additional explanations are given below for those criteria necessary to cover conditions as they apply to Region 9.

Acres. In general, areas of less than about 100 acres would not be considered as a potential winter sports site. This would include parking, improvements such as a central shelter, as well as suitable ski terrain.

A. *Snow cover or Ice.*

1. Period of sufficient snow to make sports feasible. Quality prescriptions:

		Minimum Acceptable Conditions
Outstanding	1–2	Snow cover 3 months.
Good	3	Snow cover 2 months.
Fair	4*	Snow cover 1 month.

*Minimum acceptability.

2. Snow texture.

		Minimum Acceptable Conditions
Outstanding	1	Dry snow 2/3 of season.
Good	2	Dry snow 1/2 of season.
Fair	3*	Dry snow 1/3 of season.

*Minimum acceptability.

3. Snow depth during peak period.

		Minimum Acceptable Conditions
Outstanding	1–3	Depth 2–3 feet.
Good, Fair	4*	Depth 1–2 feet.

*Minimum acceptability.

4. Snowfall as an adverse factor.

		Minimum Acceptable Conditions
Outstanding	1	No problems.
Good	2	Occasional problems.
Fair	3*	Problems at least 1/2 of season.

*Minimum acceptability.

5. Period of satisfactory open ice. We have little or none of this use. It is not necessary to rate this item.

B. *Vertical Rise of Slopes.* In this region we do not have potential ski areas with slopes having a vertical rise of more than a few hundred feet. In making ratings of different sites, cross out the last zero of all the slope classes shown on Form 19. The range of slope height will then be from 300 feet to 30 feet. Quality prescriptions will then be as follows:

		Minimum Acceptable Conditions
Outstanding	1–2	250–300 foot rise.
Good	3–4	150–200 foot rise.
Fair	5	100–150 foot rise.

C. *Steepness of Slope.* The guidelines of what are novice, intermediate, and advanced slopes are indicated on page 89 of the work plan as well as on Form 19. Quality prescriptions will be as follows:

		Minimum Acceptable Conditions
Outstanding	1	40–60% intermediate; w/adequate novice and expert slopes.
Good	2	Majority intermediate, adequate novice, some expert slopes.
Fair	3*	Majority intermediate, no expert slopes.

*Minimum acceptability.

D. *Aspect of Slopes.* Quality prescriptions:

		Minimum Acceptable Conditions
Outstanding	1	North slope.
Good, Fair	2*	East or west slope.

*Minimum acceptability.

E. *Wind Conditions.* Quality prescriptions:

		Minimum Acceptable Conditions
Outstanding	1–2	Occasional winds and drifting.
Good	3	Occasional high winds.
Fair	4*	Frequent high winds.

*Minimum acceptability.

F. *Temperatures.* Quality prescriptions:

		Minimum Acceptable Rating
Outstanding	1	Generally above 0°F.
Good	2	Above 0°F on majority of days.
Fair	3*	Below 0°F.

*Minimum acceptability.

G. *Avalanche Possibilities.* It is believed that there are no avalanche problems in this region; therefore, all potential winter sports sites can be given a rating of *1* for this.

H. *Slope Protection.* Adequate protection would be timber or terrain that would afford protection by cutting down the wind, thereby keeping

the snow from blowing from the slope, or by keeping the slope shaded, thus cutting down the possibility of undue thawing. Quality prescriptions:

		Minimum Acceptable Conditions
Outstanding	1	Adequate or not needed.
Good, Fair	2*	Adequate for most.

*Minimum acceptability.

I. *Cost of Slope Clearing.* The relative costs of clearing will be judged on the basis of the timber cover on the site as follows:

High Costs	Medium well stocked stands of mature hardwoods and pine saw timber. Well stocked stands of merchantable pole timber.
Moderate Costs	Operable, poorly stocked stands of mature hardwood and pine saw timber. Medium stocked stands of merchantable pole timber.
Lower Costs	Poorly stocked stands of merchantable pole timber, nonmerchantable pole and sapling stands of variable stocking, open areas.

Quality prescriptions:

		Minimum Acceptable Conditions
Outstanding	1	Costs low.
Good	2	Costs moderate.
Fair	3*	Costs high.

*Minimum acceptability.

J. *Ground Surface Conditions.* Quality prescriptions:

		Minimum Acceptable Conditions
Outstanding	1–2	Some work needed.
Good	3	Moderate work needed.
Fair	4*	Heavy work needed.

*Minimum acceptability.

K. *Availability of Electric Power.* For the purpose of rating this item, consider that electric power is at the site if an existing power line is within one mile. Quality prescriptions:

		Minimum Acceptable Conditions
Outstanding	1	At site.
Good	2	Available, moderate cost.
Fair	3*	Available, high cost.

*Minimum acceptability.

The following criteria as listed on Form 19 will be rated similarly as shown:

L Parking development costs.

M Convenience of parking location.

O Year-long or seasonal recreation.

Outstanding	1
Good	2
Fair	3 (Minimum acceptability)

CRITERIA FOR EVALUATING RECREATION LANDS

The following criteria as listed on Form 19 will be rated similarly as shown:

N Appurtenant service development possibilities.

P Damage to aesthetic view.

Outstanding	1
Good, Fair	2 (Minimum acceptability)

Accessibility—accessibility will be considered and rated under the same standards as prescribed for occupancy development sites.

SUBTASK 7.10
FISHERIES ANALYSIS

INTRODUCTION

Cook Inlet is one of the major spawning areas in the State of Alaska. The commercial catch of salmon reported for Cook Inlet during the five year period from 1971 to 1975 averaged over 2 million fish per year, and represented an average of 7.4 percent of the total catch for the State of Alaska during these five years. In addition to the commercial catch of salmon, the sports fishery took about 80,000 salmon a year and the personal-use fishery, an additional 10,000 salmon per year. Sockeye, pink and shum salmon are by far the most important species in the area; making up over 90 percent of the total catch from Cook Inlet; coho and chinook salmon make up the remainder. Chinook and coho, however, are most favored by the recreational fishermen.

The construction of power dams on the Susitna River can affect negatively or positively portions of the salmon runs and game fish resources of the Susitna River Basin. The studies necessary for the understanding of these effects on the game fish resources below the dam site are essentially the same as those required to protect or enhance the salmon resources in the same area. It is reported that there are no salmon stocks above Devil Canyon because of the rapids or drop in that section of the river. There are, however, game fish above that section that obviously will be affected by the creation of lakes as opposed to the free-flowing river.

The extent to which the main river will be used, both for spawning and rearing of commercial species, has yet to be demonstrated. It is known that both adults and juveniles use the river channel for transportation to their spawning and rearing areas. The lack of knowledge on the conditions is generally attributed to the turbidity of the river, which makes observations difficult and high production suspect. There may be, as there are in many streams, a winter-over capacity utilized by fish that normally reside in clear water tributaries but migrate into areas that have continuous winter flows and, therefore, this river may play an important part in their life cycle. This is a part of the needed study.

A survey of the fishery resources should cover a complete cycle. A two-year program prior to license application, although supplying essential information about the fishery, is minimal and should be continued through supplemental studies and continuation of the proposed work for a period of up to 6 years.

The fish studies proposed at this time have been based upon the establishment of an "Operations Office" in Anchorage for coordination and administration of the studies, and subcontracting portions of the studies to research groups in the University of Alaska. Portions would also be best performed by the Alaska Department of Fish and Game and other agencies. These research units are competent in the specialized disciplines required, are familiar with field conditions in Alaska and, in general, provide the most efficient base for the studies. This plan of study includes proposed research groups for the various aspects of the fisheries in-

investigations, although commitments have not yet been obtained from these groups. In the event that the proposed groups are not able to undertake the work, other qualified groups are available.

ANALYSIS OF PHYSICAL FACTORS

APPROACH

The project, as do all hydroelectric projects in which major storages are involved, has three periods that must be considered after the baseline studies have been conducted to establish the extent of the use of the river by commercial and sports fisheries. These baseline studies are required to develop criteria for protecting the fish and, perhaps, in the final period, enhancing them.

The first period is construction, the effects of which, in this case, may be minor as only road building and cofferdam building need to be considered as adding to the turbidity of the stream. This is brought about because it is assumed that no anadromous fish passage is required beyond the Devil Canyon site.

The second phase is the filling period in which many of the problems associated with the operation of the project will begin to appear, with some special problems caused by the fact that the finally-designed outlet works may not be available. To maintain a free-flowing river (free of excess nitrogen concentration and with proper temperatures) would require a more careful design of the temporary outlet works than might normally be needed. The effects of temperature, turbidity changes and excessive dissolved gases will be discussed for the operating stages, but must be considered also during the filling period.

The third phase is the plant operation, which may include only partial loading of the units initially and, hence, some spill during the period before the maximum utilization of the units.

As this is a storage project, particularly with the upper dam in place and in operation, it must be assumed that there would be regulation at this point which must be measured for its effects downstream by lowered flows during transportation and spawning, egg incubation and fry emergence, and rearing time. For some species the rearing time may be very limited as the fish leave immediately after emergence from the gravel.

The low water periods are in the winter. Under operational conditions power discharges will be superimposed on these flows, thus affecting the ice cover and, potentially, creating an area free from surface ice but with a new threat of frazil ice. Channel erosion can ensue as the normal ice cover can be increased unless the same balance of flow under power regulation matches the natural relationship of ice to normal existing low flows.

The storage undoubtedly will result in a reasonable flood control, and it is conceivable that a more permanent type of channel will result.

One of the spawning criteria associated with fluctuating flows is that eggs deposited must not be exposed, particularly to freezing conditions. The eggs and larvae must remain unmolested and continuously supplied with adequate exygen. The diminution of flows through the redds may result in the death of the eggs. After hatching, the larval oxygen requirement rises but, as the gills are still inefficient, they require a high level of saturation of oxygen, without which they may die.

If the redds were to be smothered by wash load or suspended load, which may drop and become a part of the bed by decreased velocities, the water percolation through the gravel is reduced and the eggs, larvae or alevins can be smothered, thus stable river beds and banks are required during these critical times in the life cycle. It must be noted that there are very close requirements for suitable spawning areas as to velocity, water depth and gravel size. The eggs, once laid, have a requirement of day degree temperatures to hatch; this requirement must be met. Under normal conditions this is met by the spring or early summer temperatures. The storage of water generally reduces summer temperature unless drawn specifically from the warmer surface water, or unless drawn from proper levels. The incoming water in a reservoir will seek various levels because of its density at inflow temperatures. There may also be stratification of entrapped silt because of density layering.

Because of the size of these reservoirs, it is obvious that there will be no materials brought to the river section below and it may be assumed that the channel below the structure will become a degrading channel and, hence, will be subject to attack of its bank until the bed is stablized.

The above generalized statement of the problem is intended only to indicate why there is a need to first obtain baseline data in order to answer the questions that will present themselves principally during the filling and operating periods.

To obtain baseline data, it is obvious that much of the data are needed to develop the economics of the power site, as well as to answer construction problems. While the operation of the power plant may not exactly fit the best requirements for fish maintenance or enhancement, the load levels must be known and the proposed reservoir mode regulations known. It would be senseless to duplicate any of the data on flow and temperature and it might be best merely to expand the field work to include any additional work for fisheries needs during the general hydrological studies. All physical conditions, such as reservoir capacities, are a part of the power studies and can be utilized directly for limnological purposes and should not be duplicated in the fisheries studies.

The temperature gathering usually is not a major requirement in hydroelectric studies and perhaps here the requirement of the various stocks of fish would take precedence. Unless some unusual situation exists within the reservoir, the limnological work for the fisheries would make it possible to suggest the adequate location for multiple outlets for temperature control or for the

elimination of entrapped turbidity layers. This, then, might be deemed more important to the fisheries and should be included in the fisheries studies.

To what extent power generation would be influenced by the need for maintaining stable channels if fish were not present may define the interrelationship between the needed fisheries and power investigations in the channel. Whichever appeared to have the greatest need for study should satisfy the other. The best, in fact, might be a combination study.

The question of ice cover in the river, brought about by a major development, does not have a good background experience. It would be desirable first to take a look at the literature to find the problems that may have arisen in sub-Arctic zones for high mountain areas. Frazil ice in large quantities has caused minor jams and channel changes and certainly is a problem at shallow intakes. Once the ice cover is formed over a river, it would be undesirable to have the formed conduit under the ice blocked at any point and the water routed over the ice surface, if there were fish resident in the stream or its pools, or eggs or larvae in the bed.

The end result of fluctuating flows in the river can produce an ice-free area below the powerhouse, but does not necessarily guarantee that frazil ice would not form. This ice-free area, if brought about by 4°C water from a deep intake, could result in fish coming to such an area to avoid the colder waters and bring into being a now nonexistent predator problem, if young or juvenile salmon or trout are over-wintering in the main river.

From a fisheries standpoint, we need to know the composition of the bed and whether there is a surface pavement which, if lost, would speed the stream degradation or permit rapid erosion. In other words, the stability of the initial stream bed should be measured.

The geological work in the lake, which should be undertaken to determine if any unusual outcrops of metal will be inundated, should be undertaken. It is assumed that the engineers involved in the construction will probably be more concerned with landslides than would the fisheries people; however, there have been some problems associated with landslides in lakes that have affected public safety and have also caused periods of cloudy water. As a major geological survey is to be made of the two proposed storage basins, it might be expected that the questions raised for fisheries needs could be easily answered by such surveys, or by an additional crew member rather than an additional party.

During the filling period, when water must be by-passed, or during the early part of the power generation at the project, there may be a spill. One of the major problems that has recently arisen is plunging flows into deep stilling basins which entrap air, thus bringing the dissolved nitrogen above critical level. It would be necessary to know, then, the type of spill that is proposed during

the filling period, as well as the potential for spill during the critical times for fish in the early power generation. The nitrogen problem has been corrected at the Columbia River dams, but it has been rather costly, both in money and in fish. A deep outlet, of course, could solve the problems of temperature regulation before the reservoir reaches the level set for the beginning of power generation. Parts of this study would be contained in a limnological review for partially-filled, filled and operating lake reservoirs.

The lakes will inundate a flowing stream section of the river, which may or may not be a major supplier of trout. When the lakes are filled, it would be expected that they would become a part of the recreational fisheries potential of the area. This area that is now relatively inaccessible will become accessible because of construction activities, which will permit float planes to land and take off and fishing camps to be established. These reservoirs can also be used as a jumping-off place for lakes in this watershed now fished lightly. Usually, newly-formed lakes are highly productive for a short period of time and they become well-used during this time.

The proposed study would examine the basin area above the dam site to determine specifically the extent of the fish stocks, their intermovement and interrelationships, and the general effect that these new reservoirs will have on the basin area. If the river fishery is as indicated (low) then the new areas would become more productive and it would be desirable to predict such changes for a reservoir management program.

Table 1 is an outline summary of "work items" within the fisheries analysis, primarily physical factors and impact issues to be investigated. These items are organized into three categories: baseline studies, prediction of construction impacts, and prediction of operational impacts.

TABLE 1. FISHERIES STUDIES- CHECK LIST OF NEEDED WORK ITEMS

BASELINE STUDIES (RIVER AS IS)

1. Location of spawning areas - Rearing areas, milling/Holding, intra System movement
2. Effects on channels of turbidity, bed load and flow levels, water quality

   A. Develop hydrographs at damsites and selected sites, upstream and downstream

   B. Develop hydrographs on tributary streams downstream from damsite. Turbidity levels in such streams

      (Requires gauging station or reasonable number of miscellaneous checks)

3. River cross section for typical reaches

   A. Transects
   B. River profiles
   C. Flight pictures at various river stages
   D. Maps

4. Frazil ice, if formed

5. Anchor ice, if formed

6. Ice cover - continuous or partially open

   A. Winter flows (Under the ice - over the ice)
   B. Average thickness of surface ice

7. Water temperatures

   A. Main river
   B. Tributaries
   C. Natural lakes

8. Water Quality

   A. Mineral
   B. Gas balance
   C. Turbidity (will change)
   D. Wash load estimate (will cease)

9. Bottom types

   A. Gravel sizes
   B. If a surface pavement exists

10. Bank stability, as affected by scour, flow changes

11. Geology of the reservoir areas

    A. Metal bearing strata
    B. Slide potentials

PREDICTION OF CONTRUCTION IMPACTS

1. Time of elements

    A. Cofferdam
    B. Method of river diversion
    C. Silt control
    D. General pollution control

2. Filling time

    Means of by-passing necessary flows

    A. Avoid plunging flows and excess nitrogen
    B. Temperature level of water to be passed
    C. Temperature profiles (computed)
    D. Turbidity changes (computed)

3. Water stages

    A. Runoff patterns below dam will be altered
    B. Silt content in the river areas will be altered
    C. Gas content may be altered
    D. Temperature in both summer and winter will be changed

    Day degrees needed for eggs to hatch and fish to grow (Growth pattern predictions)

4. Ice cover may be changed
    Effect of extra winter water

5. Frazil ice may present new problems

PREDICTION OF OPERATIONAL IMPACTS

1. Expected loads - such flows are related to natural flows

2. Draw down or filling

    A. Summer flow changes
    B. Winter flow changes

3. Intake level (or levels) for control

4. Expected spill, if any

5. Scour as affected by changing flow during normal flows from tributary streams

6. Bank scour

7. Icing

   New ice-free area - predation and small fish accumulation

8. Changed ice. Thickness affecting temperature and downstream movement

9. Added light and added food production

10. Potential for added productive area

11. Lost productive areas

12. Formation of new lakes, which will need to be managed - A complete study above the dams is required

FIELD SURVEYS

Field surveys of the physical factors which affect the fisheries of the Susitna River will be performed during summer and winter periods. These surveys can be divided into those to be performed downstream, i.e. below Devil Canyon (or Gold Creek) and those to be performed upstream, i.e. above Devil Canyon (or Gold Creek), in relation to the proposed dam sites. The physical factors, including flow, turbidity and temperature, and water quality measurements will be taken by R&M at their gauging stations. Additionally, temperature data will be collected as a part of all fisheries field surveys. Survey crews will also obtain data on fish populations; however, population studies are described further in a later section of this plan of study.

DOWNSTREAM SURVEYS

Salmon and steelhead ? may not now utilize the main stream channel for spawning or rearing because of either excessively fine suspended materials or wash loads. If it is found that fish are now using the stream areas, the work will be concentrated in these areas. If it is found that there is no present utilization, potential areas will be identified. These may become available owing to the fact that the suspended load may be mostly eliminated because of the large reservoirs.

Water samples will be taken (by R&M) in order to determine the changes that might take place, and to identify any trace metals that could cause problems. Dissolved oxygen and nitrogen will be examined continually.

The survey of the stream areas will include cross sections, river bed and water surface slopes and changing water levels for determining wetted area.

Winter crews will collect data to be used in the identification of any new problems that might arise from added winter flows that affect the ice cover. It is expected to utilize existing surveys, both terrestrial and aerial, and, if reference stations are not available, to utilize data from the railroad surveys for reference points to keep the surveys in balance. Reference boundaries will be set at useful areas to be included in the aerial photography to determine the relationship of flow to wetted area for use in the study of the new flow conditions to be created.

Runoff data, as has been gathered by others and augmented as necessary, will be utilized.

need winter fish dist. & movements

Tributary streams will be measured for their flow input, temperature regime and water quality.

The composition of the river bed will be examined along with typical areas of the bank for potential future scour and stability.

Winter crews will measure the depth of ice cover and the extent of open areas. The spring break-up will be followed as it may effect erosion and, hence, channel changes.

As physical requirements for a good spawning bed are known, such areas can be identified as to velocity, depth and bottom stability, and as to whether they will remain wetted throughout the critical hatching and rearing periods.

R&M will collect water quality samples throughout the year, including the winter period. If species are to be introduced into new areas of the river, they must have known tolerance levels for any known metals that may be present in the watershed.

Temperature readings will be taken in order to insure that the necessary heat (as measured in day degrees above 32°F) will be satisfied within the existing limits of the species. It has been found that less than normal temperatures at migration time slow the movement of the young in their seaward migration. The extent of any temperature shift below normal can only be determined from the as-is records and then calculated for the new regime created by the reservoir regulation.

UPSTREAM SURVEYS

Survey crews will perform the field work necessary to obtain data on fish populations and food potential in the principal recreational fishing areas. The principal species involved are Arctic Grayling, Lake Trout, Ling, Rainbow Trout, Whitefish and Dolly Varden/Arctic Char.

Physical data will include an estimate of the flow input throughout the year from important tributaries and temperature measurements throughout the watershed, including bathythermograph records within the lakes as a part of the study for determining new reservoir temperature levels. Certain key streams would be sampled to determine seasonal fluctuation in populations, growth rates and food preferred by the fish.

Fishing effort will be determined from the census cards of the Alaska Department of Fish and Game.

The winter program will be principally concerned with ice cover and water quality; both directed toward a better understanding of the conditions that will be created in the new reservoirs.

Stream measurements above the reservoir areas will be made to determine whether there exist suitable spawning areas.

ANADROMOUS FISHERIES STUDIES

APPROACH

From river surveys made during the late 1950's, it was established that salmon do not ascend above Devil Canyon, approximately 130 miles above the mouth of the Susitna River. Thus, we are not concerned with the elimination of salmon runs due to the location and height of the dam(s) but only with the effect that design and operation of the dams might have upon migration and survival of juvenile and adult salmon in the main channel of the lower Susitna River, and upon possible spawning in the main channel, although there is no report to date that such spawning exists.

There are many ways that the amount and quality of water released from dams can affect the migration and survival of salmon in the lower Susitna River. Very low flows during the winter months might seriously affect the salmon, coho and chinook, that remain in the streams and rivers for one years before going to sea.

We know that salmon frequently enter their spawning streams when there is an increase in water flow and frequently will remain off the mouth of a stream waiting for rising water. Whether this is true for a major access river, like the Susitna, is not known. The effect of temperature on the development and growth of the eggs and young salmon needs to be quantified in such form that it can be used in the design and operation of the Susitna project.

At the same time, this project presents an unusual opportunity to incorporate into the design of the dams, and their operational schedules, features that would actually enhance the production of salmon in the lower Susitna watershed. We know from experience at existing dams in the Columbia river and elsewhere that temperature of the water below a dam can be modified to favor the production of salmon by placing the turbine intake at lower depths. We are also aware that much silt will settle out in the reservoirs, providing better water for the production of salmon in the streams below. But what about the increased vulnerability of the young salmon to predation from the increased visibility? Again, as far as known, no intensive study has been made of the effect of turbidity on the survival of young salmon.

Thus, two of the studies proposed for the Susitna will be designed to define the movement of young and adult salmon through the lower Susitna River and the relation of certain environmental conditions to their migration and survival. Although difficult and complex, every effort will be made to develop a series of temperature, turbidity and flow conditions that would provide optimal conditions for salmon migration and survival in the lower Susitna River, and hopefully, the data could be incorporated with the other operational criteria of the Susitna project.

The remaining study will provide the basis for evaluation of the contribution (i.e., the importance) of the Susitna River salmon runs to the Cook Inlet fisheries - data essential to establishing the importance of the Susitna salmon to the economy of the Cook Inlet region as a whole. The only practical way to approach this

problem is by use of differences in racial characteristics between the Susitna salmon stocks and those entering the other tributaries to Cook Inlet. In this case, it is proposed that two different approaches be taken, one using differences in the growth patterns of scales and the other using genetic differences in the water soluble proteins (enzymes) as detected by electrophoretic analysis of tissue. Both of these methods have been tested and used to some extent on the Cook Inlet salmon. We know, for example, the red salmon from the Susitna river tributaries can be statistically separated from those runs to the Kenai and Kasilof rivers by both methods and a combination of the two methods will increase the accuracy of identification. The study proposed here will use both methods, supplementing existing work by increasing the size and frequency of sampling and including all five species.

Ideally, since the Pacific salmon are cyclic in years of return, these studies should continue through at least one complete cycle. Differences do occur between the different year classes. The results obtained prior to license application may show, at least, the degree of variation that might be expected from year-to-year but with wide limits of confidence. The real danger is, of course, the unpredictable conditions or events that might occur in any one year. For example, any one year could be completely abnormal with respect to weather or the fish and would make interpretation of the results very difficult. Therefore, these studies will continue through Phase II (post-license application). If time were available, the period of study should be extended for a total of six years.

CONTRIBUTION OF THE SUSITNA SALMON POPULATIONS TO THE COOK INLET FISHERIES - QUANTITATIVE SEPARATION OF STOCKS

OBJECTIVE

The objective of this study is to identify races of the Susitna River salmon taken by the commercial and recreational (including personal-use) fisheries in Cook Inlet, and to determine quantitatively the portion of the total catch originating in the Susitna River drainage.

BACKGROUND

The salmon originating in the Susitna River drainage pass through an intensive commercial and recreational fisheries, extending for about 120 miles from Anchor Point to the vicinity of the mouth of the Susitna River. The Susitna River stocks of salmon are intermixed throughout the entire fishery with other very large stocks of salmon spawning on the Kenai Penninsula, in tributaries of Kachimak Bay and along the western shore of the Inlet. Any feasibility study of the Susitna River projects will require an assessment of the contribution of the Susitna River populations to the commercial and the recreational fisheries.

WORK PLAN

Fortunately, the catch data from the commercial fisheries are relatively accurate (based on buyer's receipts) and divided into

Value must be related to areas of operation

sub-areas of capture. Records of the recreational fisheries are obtained by card census, estimated to be about 85% of the total effort, and will provide information on catch and fishing effort.

Identification and separation of the various stocks of salmon will be made by use of differences in scale patterns and genetic characteristics determined by electrophoretic analysis of tissue samples. These differences have already been found to exist in races of sockeye salmon in Cook Inlet and the runs to the Susitna river have been statistically separated from salmon from the other major spawning areas. The program calls for the regular collection of scales and tissue samples from the canneries and salmon buying stations and from the recreational fishermen in the Cook Inlet area, and from the major salmon spawning streams (both in the Susitna River watershed and from other major spawning areas).

This project will require one sampling team of two men for a four month period (May to September). The crew will require car transportation and at times, a boat or charter plane. It is estimated that a total of 6,000 scale and tissue samples will be collected from the fisheries and spawning streams (excluding the Susitna) for racial determination by the research units of the Alaska Department of Fish and Game (Anchorage) and the Department of Fisheries and Natural Resources, University of Alaska (Juneau), if it can be arranged.

Unless Sub-populations can be determined a tag recovery program must be initiated within Susitna.

PROPOSED AGENCIES

Field collections -

Alaska Department of Fish and Game, or
University of Alaska (Juneau or Fairbanks)

Laboratory analysis -

* must know stock timing

Alaska Department of Fish and Game (Research Unit, Anchorage); Scales
University of Alaska (Juneau); Electrophoretic analysis of tissue

II. Distribution & movement

DISTRIBUTION AND MOVEMENT OF ADULT AND JUVENILE SALMON IN THE LOWER SUSITNA RIVER - KNOWN SPAWNING STOCKS

OBJECTIVE

The objective of this study is to determine the location and importance of every known salmon spawning area in the lower Susitna River, the time of spawning and most important, the time and migratory pattern of the various species and races of salmon ascending the lower Susitna River on their way to the spawning grounds.

BACKGROUND

The location of all known salmon spawning areas in the lower Susitna River drainage in the early 1960's (and based on information provided by the Alaska Department of Fish and Game) is documented in a publication by the Principal Investigator (Atkinson et al. 1967). Because of the inaccessibility of much of the area and the turbidity of the water, the extent of the spawning areas and enumeration of the total escapements of many of the runs are difficult to obtain. However, the Alaska Department of Fish and Game regularly surveys the various spawning areas, frequently by plane, and obtains an index of abundance of the individual runs which are valuable in their year-to-year comparisons of the success of spawning.

This information from the annual surveys and estimates of the Alaska Department of Fish and Game continue to be available and would form the base for this study.

The migratory pattern or length of stay in freshwater for the various species of salmon becomes very important in the design and operational schedule of dams proposed on the Susitna River. So far as known there is no information available on the migration of young salmon out of the Susitna River. We know that sockeye salmon will remain for one year or more in lakes or "springs" located near their spawning grounds. Pink salmon migrate to sea immediately after emerging from the gravel, and frequently spawn in intertidal areas. Chum salmon frequently spend a short time in fresh water and may feed during this period of residence. Chinook and coho salmon young will spend a year or more in residence in the freshwater streams or rivers, migrating to sea in their second year of life. If young chinook and coho remain in the lower Susitna River during their period of freshwater residence, then the design and operational schedule of the proposed dams should be such as to assure an adequate supply of water for the fish all year around. If, on the other hand, it was found that the young coho and chinook spend most of their juvenile residence in the tributary streams, then the flow from the dam can be operated with considerably more flexibility.

At the same time, very little is known of the migratory pattern of the adult salmon as they leave Cook Inlet and move upstream on their way to their "home" streams. For example, some races of salmon are known to move very rapidly through a river system; other races will move slower, frequently going in and out of the mouth of a river several times before the final migration upstream. There is a very significant difference between the rates of migration of those fish entering the river first and the "late" arrivals. This migration pattern becomes extremely important in this case since the amount of water to be released from the dams must be completely adequate at all times to guarantee the salmon easy migration through the lower Susitna River.

WORK PLAN

This study will require a very close coordination with the management biologists of the Alaska Department of Fish and Game, and the Department should be encouraged to expand the number of observations made of the various spawning grounds, with support, if necessary, from this program.

absolutely essential!

It is felt that an estimate of the total escapement to the Susitna River would be useful in this study, but not essential. We are more interested in the movement of salmon upstream and for this, it is suggested that a tagging experiment might be most practical, using a coded wire tagged on the adults with recoveries mainly from the personal-use fishery along the Susitna river. Salmon for tagging can be obtained from the fish wheels operating near the mouth of the river. It would be difficult to obtain tags from the various spawning areas because of the general inaccessibility of the areas, but dead salmon, where they accumulate in any quantity, might offer some possibility of recovery.

B.S.

Finally, it is proposed to try to trace to movement of certain races of salmon upstream by identifying certain "gene-types" associated with the electrophoretic analysis of tissue.

— and at all times.

The downstream migration of young salmon will be determined by fishing large fyke nets at two or three stations along the Susitna River, and the collections will be supplemented by the use of beach seines and electric shocking equipment. Information will be obtained on age, size, sex, etc., specimens retained for stomach analysis, and tissue samples taken for electrophoretic analysis to determine racial origin.

One crew of two men will be assigned to the field work with the close coordination with the Alaska Department of Fish and Game.

III

Dist. & recommend

PROPOSED AGENCY

Alaska Department of Fish and Game
University of Alaska (Juneau and Fairbanks)

* unknown spawning likely most important

DISTRIBUTION AND MOVEMENT OF ADULT AND JUVENILE SALMON IN THE LOWER SUSITNA RIVER - UNKNOWN SPAWNING STOCKS

OBJECTIVE

The objective of this study is to discover unknown salmon spawning areas in the lower Susitna River proper and the associated characteristics of the river channel and the extent the area might be affected by the proposed water projects.

BACKGROUND

Available information limits all known salmon spawning areas to the various tributaries of the lower Susitna River. No salmon spawning areas have been reported from the lower Susitna River channel proper.

The presence or absence of spawning grounds in this portion of the river must be confirmed beyond all reasonable doubt. If salmon spawning grounds in the main river are not known nor not reported in this study but later discovered and verified by outsiders, then there would arise a problem of credibility for the entire study; if spawning grounds are discovered in the main channel, then provisions must be made for maintenance and even expansion of the spawning areas and must be taken into consideration in the design and operation of the proposed dams.

WORK PLAN

Although the field crews associated with other aspects of the fisheries program and the staffs of the Alaska Department of Fish and Game and the U.S. Fish and Wildlife Service should be alerted to our search for salmon spawning grounds in the lower Susitna river, the best approach to this kind of a problem would be to offer a reward of, say, $1,000 for anyone discovering a new salmon spawning area that can be verified in the field by our own field crew or the management staff of the Alaska Department of Fish and Game. In addition to the discovery of possible spawning areas, the excitement of a reward would draw attention to the program and our efforts to obtain the best information possible.

PROPOSED AGENCY

Program Direction Unit (internal), in cooperation with the Alaska Department of Fish and Game.

RELATION OF ENVIRONMENTAL CONDITIONS TO THE ABUNDANCE AND SURVIVAL OF ADULT AND JUVENILE SALMON IN THE SUSITNA RIVER - FRESHWATER ENVIRONMENT

OBJECTIVE

The objective of this study is to examine the relation of temperature, turbidity, food, predation and similar environmental factors on the abundance and survival of adult and juvenile salmon in the Susitna river.

BACKGROUND

This is a very broad subject which has occupied the attention of a number of researchers, and the relation between the various environmental factors and the survival and abundance of salmon is still not clearly understood. For example, turbid water, which is characteristic of the Susitna river, is frequently low in food production but the poor visibility in turbid water may well act as a screen against predators. There is a relation, of course between temperature, food and growth, and the larger the young fish, the less vulnerable they are to predation. Many of these factors have been studied independently but there has been little success in trying to relate the combination of factors to the ultimate survival of young salmon.

Similarly, for adult salmon, we know that stream flow (and perhaps precipitation) is an attractant for adult fish to enter a stream and begin the migration upstream. We know that higher stream flows with faster current will require a greater effort for the salmon to ascend a stream and if the current or obstacles require too much energy, the salmon, with its limited energy supply will die enroute, unspawned.

Although difficult to obtain and analyze, this kind of information is essential to the Susitna Project since it establishes the criteria needed in the design and operation of the proposed dams.

WORK PLAN

In this study, more than in the other proposed studies, much isolated work has been done over the years by various research laboratories. The publications are scattered and the information fragmentary but the knowledge of these previous studies could avoid costly duplication of work and supplement the proposed studies. Accordingly, an intensive review of the literature will be performed to compile a summary of the state of the knowledge.

At the same time that the various "laboratory" experiments are in progress, the field crew making the study of movement and survival of juvenile and adult salmon in the lower Susitna River will be responsible for the collection of juvenile samples for stomach contents, age, size and sex, etc. The information collected from the temperature, water, and turbidity gauges (by R&M) will be forwarded directly to the Operations Office.

PROPOSED AGENCY

University of Alaska (Juneau, Fairbanks or Seward) in cooperation with the appropriate field crews of the Alaska Department of Fish and Game.

RELATION OF ENVIRONMENTAL CONDITIONS TO THE ABUNDANCE AND SURVIVAL OF ADULT AND JUVENILE SALMON IN THE SUSITNA RIVER - ESTUARINE ENVIRONMENT

OBJECTIVE

The objective of this study is to examine the relation between the temperature, food, salinity, predation and similar environmental factors to the movement of young salmon through the estuarine area and their survival.

BACKGROUND

There is a growing evidence to show that one of the most critical stages in the survival of salmon occurs during the estuarine period of life. The release of young salmon from the hatcheries in Japan is timed to coincide with periods of plankton bloom in the estuaries. The International Pacific Salmon Commission has conducted extensive studies of the relation between survival of young pink salmon and the food present during their stay in the delta area of the Fraser River. In this study, the observations should concentrate on the

relation of stream flow to the extent of the estuarine area, the relation of stream flow to the production of planktonic food for the young salmon and how long the young salmon would normally remain in the estuarine area. The information will be used to establish optimum water flows for the passage of the young salmon through the estuarine area.

The passage of the adult salmon through the estuary does not appear to be as critical as for the young salmon but certainly, as mentioned previously, the amount of water flow, or fluctuations in flow, will attract the adult salmon into the rivers to begin their spawning migration.

only 3 people!

WORK PLAN

One team, composed of a Study Leader and two assistants, will conduct the study of young and adult salmon passing through the estuarine area and in the lower reaches of the Susitna River. Basically, the study will consist of measuring the salinity, temperature, possibly the chemical composition of the water, and the amount of planktonic food present and the amount and kinds being taken by the young salmon during their stay in the estuarine area.

How do we average this?

Although later modification may be made to the experimental design proposed at this time, tentatively the study will call for the definition of estuarine conditions during periods of high, average and low discharge flows from the Susitna River and during high, mean and low tides. The station pattern would consist of three transects at and off the mouth of the Susitna River, of five stations each, and five river stations with the upper station above the influence of salt water.

How do we know this?

Both the juvenile and adult salmon should be present in the estuarine area at the same time. The juvenile salmon will be sampled by small trawl (or other gear) and the adults by test gill net/purse seine fishing in the estuary and fish wheel in the Susitna River proper. The passage of runs of salmon through the estuary and river may be obtained from catch and effort data.

PROPOSED AGENCY

Institute of Marine Science (Dr. Tsuneo Nishiyama, Fisheries Oceanographer), University of Alaska (Fairbanks)

BIBLIOGRAPHY[1]

Arctic Environmental Information Data Center (University of Alaska). 1974. Alaska regional profiles: Southcentral Region. (Prepared for the Office of the Governor, State of Alaska). University of Alaska, Arctic Environmental Information Data Center (Anchorage). Volume II. 220 pages (approx.)

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1. References and background material used in the preparation of the anadromous fisheries proposal but not cited per se, except Atkinson et al. (1967).

Atkinson, C. E., J. H. Rose and T. O. Duncan.
1967. Salmon of the North Pacific Ocean: Part IV. Spawning populations of North Pacific salmon. 4. Pacific salmon in the United States. International North Pacific Fisheries Commission (Vancouver, B.C.), Bulletin 23. 223 pages.

Bethe, M. L., and P. V. Krasnowski
1979. Stock separation studies of Cook Inlet sockeye salmon based on scale pattern analysis, 1977. Alaska Department of Fish and Game, Informational Leaflet 180. 31 pages.

Donnelly, R. F., K. R. Johnson and D. E. Bevan.
1979. Stock separation studies. (Use of electrophoretic methods to identify pink salmon stocks). In 1978 Research in Fisheries. University of Washington (Seattle), Contribution No. 500 (March 1979). Page 24 and 25.

Krasnowski, P. V., and M. L. Bethe.
1978. Stock separation studies of Alaskan salmon based on scale pattern analysis. Alaska Department of Fish and Game, Informational Leaflet No. 175. 37 pages.

Namtvedt, T. B., N. V. Friese, D. L. Waltmyer and K. A. Webster.
1978. Investigations of Cook Inlet sockeye salmon. Alaska Department of Fish and Game (Anadromous Fish Conservation Act, Project No. AFC-53). 123 pages.

Tyler, R. W.
1961. Cook Inlet tagging. In Research in Fisheries 1960. University of Washington (Seattle), Contribution 116. Pages 28 and 29.

Yancey, R. M., and F. V. Thorsteinson.
1963. The king salmon of Cook Inlet Alaska. U.S. Fish and Wildlife Service, Special Scientific Report - Fisheries, Number 440. 18 pages.

RESIDENT FISHERIES STUDIES

Although data on resident fish populations will be collected in conjunction with the studies of physical factors previously described, several studies warrant individual descriptions. Following are summaries of studies to be performed concerning (1) the composition and abundance of resident fish populations and (2) the presence (or absence) of endangered fish species. These studies are scheduled to be performed during Phase I (pre-license application).

COMPOSITION AND ABUNDANCE OF THE RESIDENT POPULATIONS OF FISH IN THE UPPER SUSITNA RIVER

OBJECTIVE

To survey the populations of resident fish in the upper Susitna river drainage, determine the species present and their relative abundance, and assess the loss to the streams that will be flooded by the proposed reservoirs.

BACKGROUND

The upper Susitna River became an important recreational fishing area after the construction of the Alaskan Highway between Delta and Valdez. In 1978, about 45,000 fishing days effort was spent in the upper Susitna for recreational fishing with a catch between 35,000 and 40,000 fish - Arctic Grayling, Lake Trout, Ling, Rainbow Trout, Whitefish and Dolly Varden/Arctic Char, in order of importance. It is believed, however, that most of the areas presently heavily fished are located near the headwaters of the upper Susitna and not in the more inaccessible area to be flooded by the proposed dams.

WORK PLAN

The upper Susitna covers rugged, isolated terrain and will be difficult to survey adequately. The area to be flooded should be surveyed in some detail; the upstream area should be sampled rather grossly but sufficient for comparison with the streams that will be flooded. Certain key streams should be sampled several times during the year to determine seasonal fluctuations in abundance. The fishing effort and catch will be determined from the census cards of the Alaska Department of Fish and Game.

To adequately cover the upper Susitna watershed, it is proposed to use four survey teams of three men each in addition to the Survey Chief, and support personnel for supplies and communications. The upper Susitna is accessible in one area by car (the Alaskan Highway) and by float planes on the several lakes. The crews will need to establish base camps, with radio communication and protection from marauding bears. The crew will, of course, need the usual limnological equipment and fishing nets and electric shocking equipment. Most of the survey work will be conducted in the summer months.

PROPOSED AGENCY

Alaska Cooperative Fishery Unit (Federal-State-University), University of Alaska (Fairbanks)

PRESENCE (OR ABSENCE) OF ENDANGERED SPECIES

OBJECTIVE

The objective of this study is to conduct a thorough search of the Susitna River watershed for the presence (or absence) of endangered fish species, determine the effect of the proposed dams on the survival of those species and make recommendations of methods, if possible, for their protection.

BACKGROUND

The Endangered Species Conservation Act of 1969 and subsequent regulations give the Secretary of Interior broad powers to protect a species of fish whose existence is threatened with destruction, drastic modification, or severe curtailment. The extent of these powers are already well-demonstrated by the famous case of the snail darter. Accordingly, every effort must be made to determine if any endangered species lives within the area to be inundated by the reservoirs, or in the lower Susitna river. If such species are found in this area, then recommendations should be made of methods that would adequately offset any threat or loss of the species.

WORK PLAN

The study will require, first of all, a careful review of the endangered species list to determine those species, if any, which one would expect to find in the area affected by the proposed Susitna water project. If any endangered species is suspected to live within the area of study, a special effort will be made by the various field crews, perhaps supplemented by a special search team, to discover the presence of the species and the extent of its distribution within the watershed. Remedial measures might include the establishment of a special sanctuary for protection and propagation of the species, the transplant of the species to another area, or similar plans.

It is very important, in order to establish credibility to the findings and recommendations, that this study be made by a recognized expert in the taxonomy and distribution of Alaskan fishes. In addition, this investigator will require some technical assistance for review of the literature, examination of specimens and the possible field collection.

PROPOSED AGENCY

Taxonomist (Dr. Willimovsky, University of British Columbia, or Dr. Morrow, formerly University of Alaska)

ADDENDA

TO SUBTASK 7.10

FISHERIES ANALYSIS

SPAWNING CRITERIA

The general requirements are an environment in which the adults are able to spawn with a minimum of molestation, the nest is protected during the egg incubation period, the newly-hatched fry are sheltered, and growth and migration are allowed to proceed without interruption.

Salmonoid fish are gravel nest builders.

As oxygen is a requirement for egg development and for support of newly-hatched juveniles, streams that have oxygen levels of near saturation are the best producers. Supersaturation of nitrogen above a level of 104 ppm is dangerous.

Silt has a negative effect on spawning conditions.

In general, salmon and trout spawn in the same general stream areas, with depth factors somewhat commensurate with the weight of the fish. Trout select areas ranging from 6 inches to 2.5 feet in depth; salmon spawn between ranges of 9 inches and 3.5 feet.

Generally, the velocity at the bed of the stream (over the spawning bed) is less than the sustained speed of the fish, which gives velocities ranging between 1.5 and 3 fps. As stream bed composition is a factor of slope and flow (quantity) the spawning bed composition may vary from .75 inch diameter to 4 inches diameter on a normal grading curve. The beds are usually constructed in stable areas of a stream at riffles or reaches. Deposited eggs may be destroyed if the beds become dried, frozen or devoid of oxygen during the incubation period. Eggs kept damp and supplied with oxygen will hatch, but the newly hatched fry require flowing water for survival.

The redds vary in size as shown in the following table:

* Approximate weight in pounds, average area of redds, and area recommended per spawning pair for artificial spawning channels, for several species of fish by various authors.

Species	Reference	Approx. Average Wt.-lbs.	Average Area of Redd - sq. yds.	Area recommended per spawning pair-sq. yds.
Chinook				
a. summer & fall run	Burner	25	6.1	24
b. spring run	"	15	3.9	16
Coho	"	9	3.4	14
Chums	"	10	2.7	11
Sockeye	"	3	2.1	8
Chinook (spring run)	Chambers et al		13	
Pinks	Hourston MacKinnon	5	0.7	0.7
Trout	Stuart	1(?)	0.3	2

*Clay, C.H., "Design of fishways and other fish facilities." Canada Department of Fisheries, Ottawa. 1961.

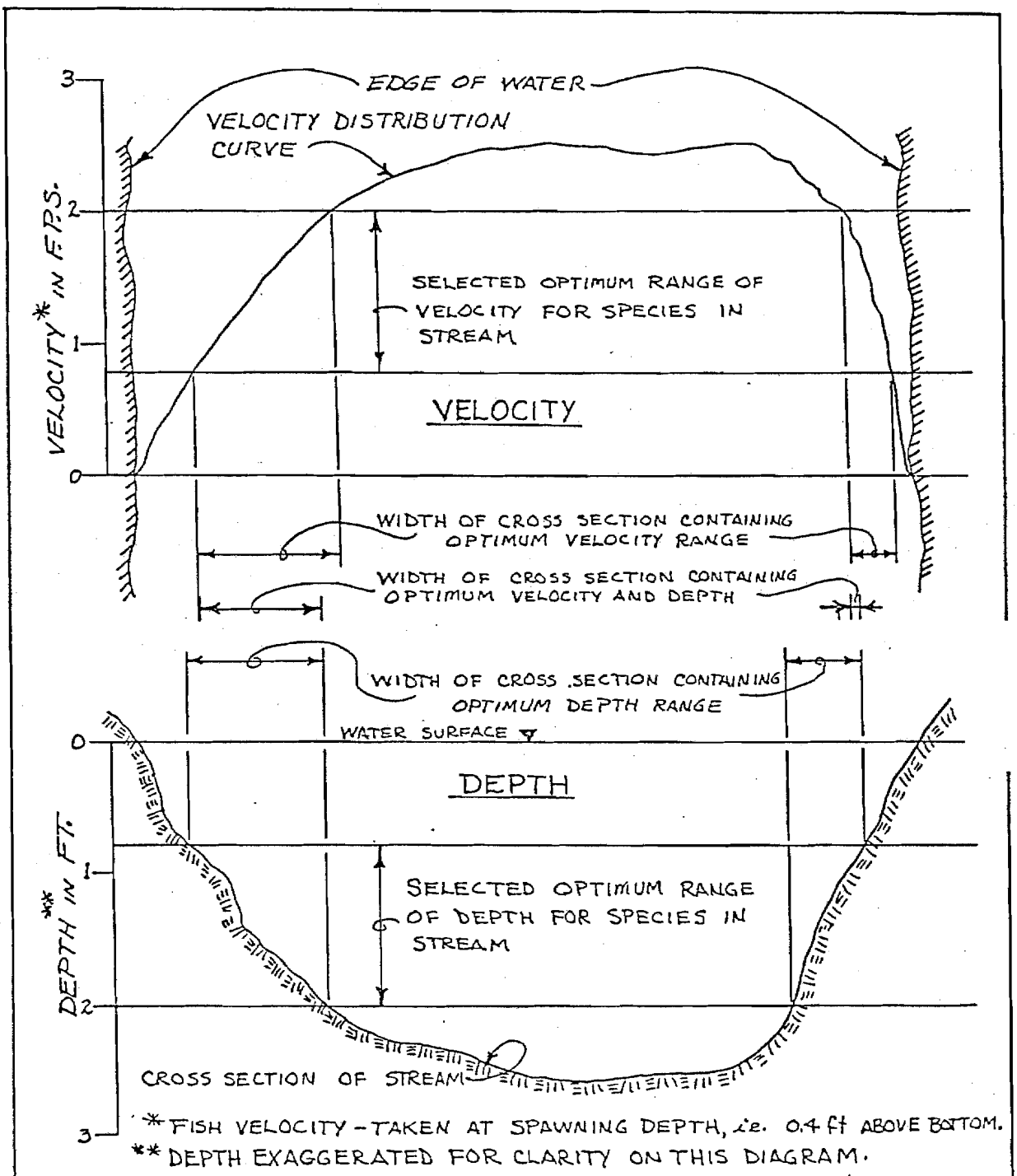
During the spawning act a defense area is enforced by the spawning pair against encroachment. The general size of this area is shown in the above table. In the best spawning areas in streams, redds may overlap by subsequent spawners. The eggs are laid in clusters and covered by gravel. A square foot of good spawning bed contains from 125 to 200 eggs. False redds may be dug and abandoned; pink salmon particularly are noted for this phenomenon. When spawning grounds are overcrowded, spawning may occur in undesirable areas, resulting in little or no production. If fish are denied access to proper spawning grounds, females may die unspawned or the eggs may be deformed.

Temperature is a major factor in success of spawning, and during their tender stage, eggs are particularly sensitive to adverse temperature changes.

The physical measurements of spawning grounds have been taken from a number of sources and represent hundreds of measurements of desirable spawning reaches of river. Velocities, depths and flows must match the timing of runs and temperature requirements. Absence of one of these factors is sufficient to negate the effectiveness of others.

Anadromous stocks, which do not feed from the time of entry into fresh water, live on their stored energy.

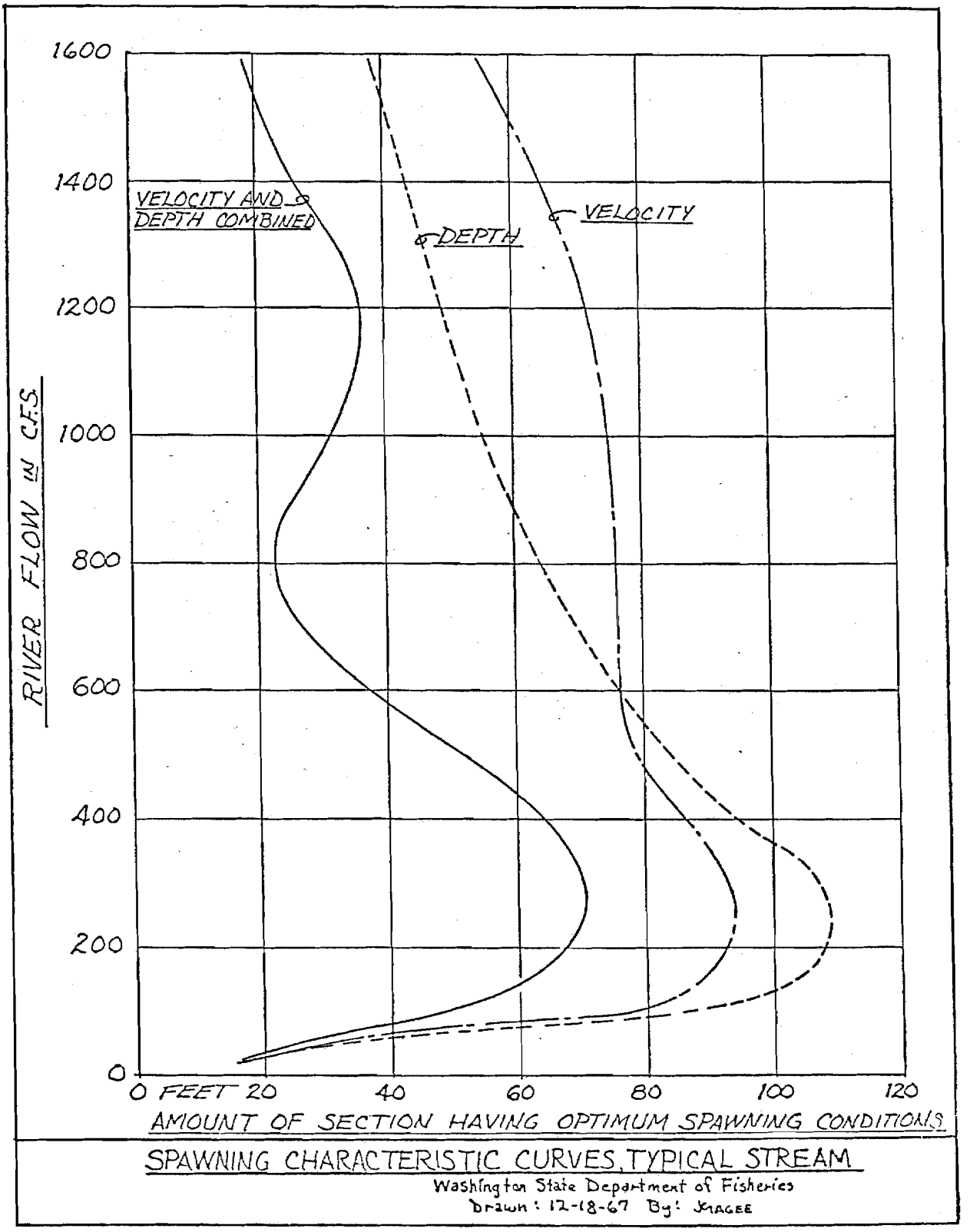
Figure 1



METHOD OF APPLICATION OF OPTIMUM CRITERIA TO A PARTICULAR STUDY SECTION.

Washington State Department of Fisheries,
Drawn: 12-19-67 By: JHAGEE

Figure 2



SPAWNING CHARACTERISTIC CURVES, TYPICAL STREAM

Washington State Department of Fisheries
Drawn: 12-18-67 By: JHAGEE

REFERENCES

Chambers, John S., George H. Allen, and Richard T. Pressey, "Research relating to study of spawning grounds in natural areas." Washington Department of Fisheries, Unpublished Annual report to U. S. Army Corps of Engineers, Contract No. DA 35026-Eng-20572. Olympia. 1955.

Pressey, Richard T., John S. Chambers, and George H. Allen, "Research relating to study of spawning grounds in natural areas." Washington State Department of Fisheries, Unpublished Progress report, February 1 to March 1, 1955, to U. S. Army Corps of Engineers, Contract No. DA 35026-Eng-20572. Olympia. 1955.

Mottley, C., "Loss of weight by rainbow trout at spawning time." Transactions of the American Fisheries Society, 67:207-210. 1937.

McNeil, William J., and Warren H. Ahnell, "Success of pink salmon spawning relative to size of spawning bed materials." U. S. Fish and Wildlife Service, Special Scientific Report - Fisheries No. 469. Washington, D. C. January, 1964.

Olson, P. A., and R. F. Foster, "Temperature tolerance of eggs and young of Columbia River chinook salmon." Transactions of the American Fisheries Society, 85:203-207. 1955.

Terhune, L. D. B., "The Mark VI groundwater standpipe for measuring seepage through salmon spawning gravel." Fisheries Research Board of Canada, Journal, 15(5):1027-1063. September, 1958.

Coble, Daniel W., "Influence of water exchange and dissolved oxygen in redds on survival of steelhead trout embryos." Transactions of the American Fisheries Society, 90(4):469-474. October, 1961.

McIrvin, Ronald David, "Fine particle movement through a granular bed." MS thesis. University of Washington, Seattle, Washington. 1965.

Sheridan, William L., "Waterflow through a salmon spawning riffle in Southeastern Alaska." U. S. Fish and Wildlife Service, Special Scientific Report - Fisheries No. 407. Washington, D. C. 1962.

Sheridan, William L., "Relation of stream temperatures to timing of pink salmon escapements in Southeast Alaska." H. R. MacMillan Lectures in Fisheries - "Symposium on pink salmon," pp. 87-102. University of British Columbia, Vancouver. 1962.

Wickett, W. P., "Review of certain environmental factors affecting the production of pink and chum salmon." Fisheries Research Board of Canada, Journal, 15(5):1103-1126. September, 1958.

Canada Department of Fisheries, "Puntledge River: the fisheries problems associated with the power development of the Puntledge River, Vancouver Island, B.C." Vancouver, B.C. October, 1958.

Burner, C. J., "Characteristics of spawning nests of Columbia River salmon." Fishery Bulletin, 52(61):97-110. Washington, D. C. 1951.

Krokhin, E. M., and F. V. Krogius, "Study of the basin of the Bolshaya River and its salmon spawning places." Translated by Dmitri Khrenov (March 1950) from Bulletin of the Pacific Scientific Institute of Fisheries and Oceanography (U.S.S.R.) 9:3-150. 1937.

Vaux, Walter G., "Interchange of stream and intragravel water in a salmon spawning riffle." U. S. Fish and Wildlife Service, Special Scientific Report - Fisheries No. 405. Washington, D. C. March, 1962.

McNeil, William J., "Effect of the spawning bed environment on reproduction of pink and chum salmon." U. S. Fish and Wildlife Service, Fishery Bulletin 65(2):495-523. Washington, D.C. 1966.

Salo, Ernest O. and William H. Bayliff, "Artificial and natural production of silver salmon (Oncorhynchus kisutch) at Minter Creek, Washington." Washington State Department of Fisheries, Research Bulletin 4. January, 1958. (revision of the senior author's Ph D thesis)

McNeil, William J., "Environmental factors affecting survival of young salmon in spawning beds and their possible relation to logging." U. S. Fish and Wildlife Service, Bureau of Commercial Fisheries, Manuscript report no. 64-1. Washington, D. C. April, 1964.

TEMPERATURE - EFFECTS ON FISH

Natural environmental temperature changes impose stresses on fish populations. Over many years various species and subspecies have adjusted to upper and lower levels, within which are optimum ranges. Exhibits A to K show ranges for fish common to the Pacific Coast regions.

When natural or artificial phenomena cause shifts away from optimum ranges, the populations are depressed. Usually, under natural cyclic conditions, the stressing is not repeated in successive years.

In dealing with cold-water species, it has been found that adults may die unspawned if subjected to long periods of higher than normal temperatures. Adult fish have been known to cease migrating when subjected to extreme temperatures.

During the egg's tender stage, which may exist during the first half of the incubation period, elevated or lowered temperatures from the upper or lower tolerance range result in increased mortalities. During this stage, a sudden raising or lowering of temperatures can cause excessive mortalities.

Spawning may cease if the temperature drops near or below the lower tolerance range.

Growth of the young is also related to temperature levels. Generally, all cold-water fish cease growing at temperatures above 68° F. because of increased metabolic rate.

As temperature affects the gas equilibrium in water, a nitrogen embolism can be caused and oxygen deficiencies created.

Heat is a synergistic effect and must be considered when measuring other stresses within the environment.

Fish are capable of sensing a temperature differential of less than $.5^{\circ}$ F.

SILT AND TURBIDITY

In considering the effects of transported sediments on stream beds and fisheries, it is necessary to distinguish between the types of sediment.

> Bed load is material moving on or near the bed. It may consist of materials rolled or slid along the bed in substantially continuous contact with the bed.
> Turbidity is caused by fine materials, mainly inorganic, although it also can be caused by organic materials, or a combination of both.

Turbidity should not be confused with water color, which is due to staining action. Pigment extracts from vegetation often occur in solution in acid swamps and bogs, imparting a brown color to waters emanating from them. Dyes and other highly colored substances frequently present in industrial wastes also may stain water. Since pigments in solution, as well as particles in suspension, reduce the amount of light transmitted, the color of water affects turbidimeter readings, making them too high.

Turbidity in lakes and reservoirs commonly is determined as that depth at which a Secchi disc reading is obtainable. There are at least three recognized methods of measuring turbidity. Where the Jackson turbidity meter is used, the assumption has been made that one Jackson Turbidity Unit (JTU) is equal to one ppm on a silica scale. Other methods give readings in parts per million or weight per unit volume.

Sedimentation is a result of the settling-out or deposition of suspended materials. This occurs mainly in quiet waters, as lakes, reservoirs, and stream sections with low velocities. Particles causing bed load or turbidity may be deposited or suspended, depending on the velocity, and become interchangeable.

The sedimentation rates follow Stokes' Law and depend upon (1) the density of the fluid (water) through which the particle is falling, (2) the density or relative weight of the particle, that is, the specific gravity of the particle, and (3) the size of the particle. A sedimentation time of one hour usually is used as an index. As the density of water varies with temperature, a correction must be made.

Some reservoirs are so constructed that they can be flushed periodically to remove the accumulated sediment. When such reservoirs are located upstream from the spawning areas of anadromous fish, the resultant heavy load of silt deposited downstream during flushing may interfere with spawning and seriously reduce successful egg incubation.

Silt may occur as a result of natural causes, such as land slides, the washing of glacial flour and normal bank cutting or bed ero-

sion. In addition silt materials can be deposited from mining activities, gravel washing, land use and forestry practices.

Excess turbidity from organic materials in the process of oxidation may reduce oxygen below safe levels.

Relatively large quantities (500 to 1,000 ppm) of suspended waterborne material can be carried for short periods of time without detriment to fish. The catch of fish is affected above levels of 30 JTU, as visual references are lost. Primary food production is lowered above levels of 25 JTU.

The effect of bed load is not so well defined by ppm or volume. Its presence can kill buried eggs or alevins by denying water interchange and can smother food organisms.

Experimental data indicate that in the Scott River, California, the organisms, which averaged 249 per square foot above the silt-laden tributary, were reduced to 36 organisms below. This is verified by work below placer mines in Alaska, where fine materials were deposited on the bed of a stream. It was found in the Stilliguamish River in Washington that 50 to 100 percent of the eggs deposited were lost, owing to the low permeability of the river bed below a natural slide. Work in Bluewater Creek in the State of Montana has indicated that when the sediment load in the stream was reduced, the trout production was materially increased and the rough fish production reduced. Studies conducted after a natural slide in the Chilcotin River in British Columbia indicated that salmonoid fish will not move in streams where the silt content is above 4,000 ppm. Streams with silt loads averaging between 80 and 400 ppm should not be considered good areas for supporting fresh water fisheries; streams with less than 25 ppm may be expected to support good fresh water fisheries.

The following is a comparison of lake production and turbidity levels:

	pounds of fish per acre
Clear lakes below 25 ppm	160
Intermediate lakes (25 to 100 ppm)	94
Muddy lakes over 100 ppm	30

Some species of fish will not spawn in excessively turbid water, such as bass and bluegill. Female salmon and trout, in the course of their prespawning activity, will wash the silt away from the gravel in the redd. However, when the deposition of an excess amount of silt occurs throughout the redd after spawning has been completed, there is a resultant interference with the proper percolation of water upward through the redd, loss of dissolved oxygen, and lack of proper removal of catabolic products. This "smothering" of eggs also promotes the growth of fungus, which

may spread from dead eggs throughout the entire redd. The extent of the harmful effects of siltation on the spawning and egg incubation of salmon and trout depends upon the amount and type of material deposited, as well as the time of occurrence. When silt contains clay particles, resembling loam, it may form a hard, compact crust over the stream bed which spawning fish are unable to remove, thus rendering the spawning area unusable. The same condition may occur when organic materials, such as wood pulp fibers, are mixed with silt, forming an impenetrable mat over the spawning rubble. Silt also may contain toxic residues from industrial or agricultural wastes which may be lethal to developing eggs and alevins.

Generally, salmonoid eggs will suffer a mortality of 85 percent when 15 to 20 percent of the voids are filled with sediment. Properly constructed sediment basins, built in connection with road building activities, gravel wash and mining operations, which effectively remove the sediment, are recommended to eliminate this source of silt.

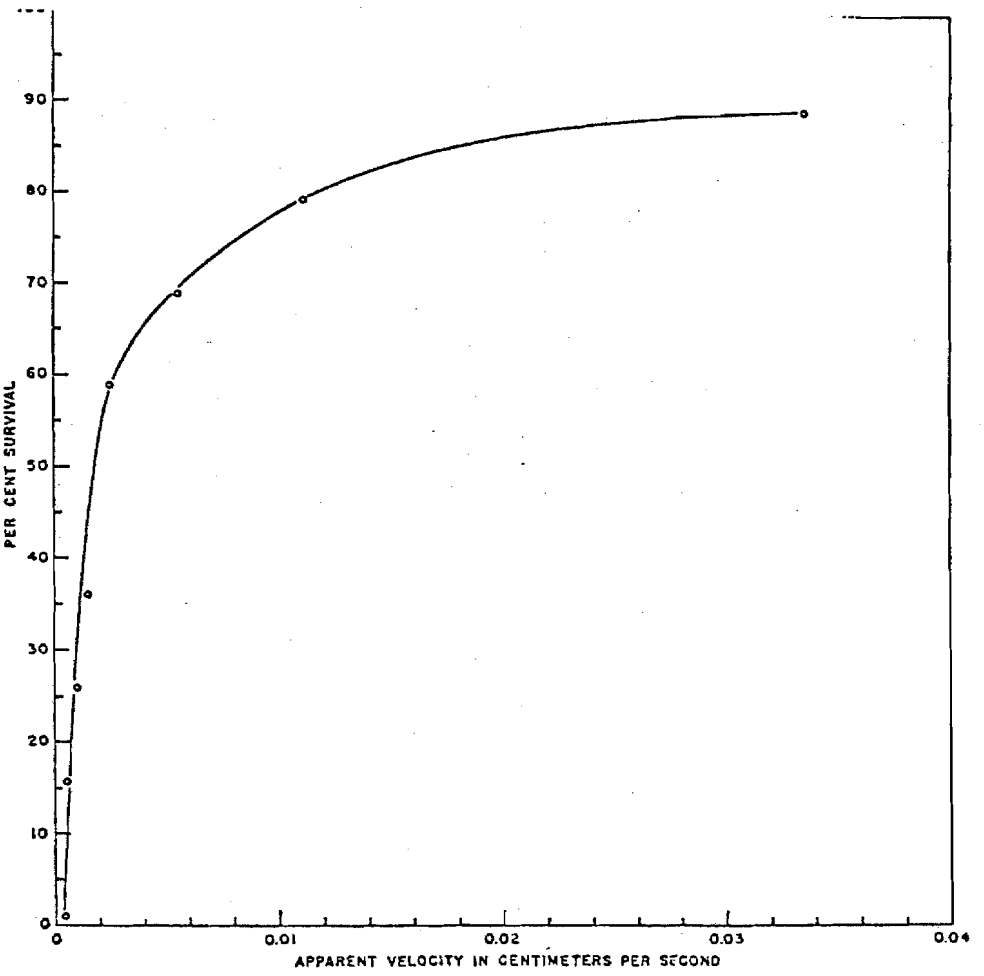
Most experimental work has shown that whereas fish can survive high concentrations of suspended matter for short periods, prolonged exposure to some types of materials in most species results in a thickening of the cells of the respiratory epithelium (so-called clubbed gills) and the eventual fusion of adjacent gill lamellae, definitely interfering with respiration. Fish do not have gill cleaners for removing foreign matter, and must rely on the flow of water through the gill chambers, the production of lubricating mucous and intermittent "coughing." Evidence of gill irritation in trout and salmon fingerlings held in turbid water has been noted frequently by fish culturists, and is considered a common avenue of infection for fungi and pathogenic bacteria.

It is apparent that some species, such as salmon, suffer more physical distress in turbid water than do others.

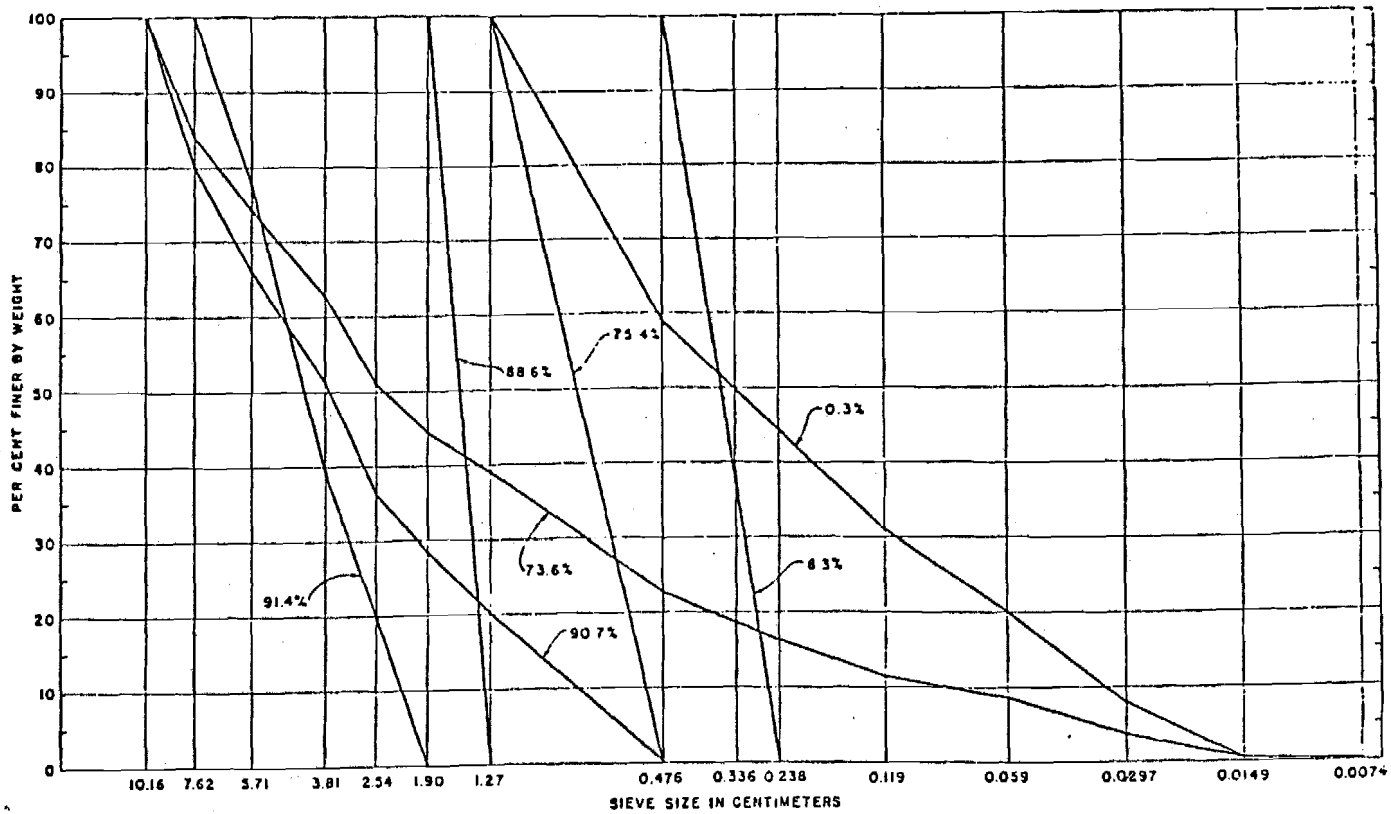
Fine materials that cause turbidity are detrimental in hatchery operations, coating the eggs and thus reducing the necessary oxygen interchange.

Figure 1 gives a graphic presentation of survival versus apparent velocity through the gravel redds.

Figure 1



Relation between rate of flow of water through a gravel bed and the survival of eyed sockeye eggs in the gravel.



Grading curves of seven experimental gravels and survival of sockeye eggs in these gravels at a uniform water velocity of 0.0167 cm/sec.

Figure 2

REFERENCES

Cooper, A. C., "The effect of transported stream sediments on the survival of sockeye and pink salmon eggs and alevin." International Pacific Salmon Fisheries Commission, Bulletin XVIII. New Westminster, B. C. 1965.

Marcuson, Pat, "Stream sediment investigation." Montana Fish and Game Department, Fisheries Division, South Central Montana Fishery Study. Job Completion Report, Research Project Segment. Project No. F-20-R-13, Job No. III. Helena, Montana. Unpublished. October 1, 1967 through September 30, 1968.

Peters, John C., "The effects of stream sedimentation on trout embryo survival." Montana Fish and Game Department, Billings, Montana. 1962.

McIrvin, Ronald David, "Fine particle movement through a granular bed." M.S. thesis. University of Washington, Seattle, Washington. 1965.

Heg, Robert T., "Stillaguamish slide study: summary of data obtained by Research Division during 1952." Unpublished report. Washington Department of Fisheries, Olympia, Washington. 1952.

McNeil, William J., "Environmental factors affecting survival of young salmon in spawning beds and their possible relation to logging." U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries, Manuscript Report No. 64-1. Washington, D.C. April, 1964.

U.S. Federal Water Control Administration, Northwest Region, Alaska Water Laboratory, "Effects of placer mining on water quality in Alaska." College, Alaska. February, 1969.

Kuenen, P. H. and F. L. Humbert, "Bibliography of turbidity currents and turbities." in "Turbidities" (Developments in sedimentology," Volume 3), editied by A. H. Bouma and A. Brouwer.

Smith, Osgood R., "Placer mining silt and its relation to salmon and trout on the Pacific Coast." Transactions of the American Fisheries Society, 69:225-230. 1939.

The above are a few selected references. There are a number of on-going studies on the effects of siltation on salmonid fish, only some of which have been published. They are not yet annotated, but are available for review and use in the Susitna project.

TOXICITIES OF ELEMENTS AND COMPOUNDS

	Remarks
Barium	Appears to be less cumulative in the body than some other metallic poisons. Indications are that in the carbonate or sulfate form it is relatively insoluble and therefore not apt to be present in solution. In Washington most streams contain sufficient bicarbonate to precipitate all but minute amounts of barium. Could be present in colloidal suspension, a chelate, an organic compound, or in other ways.
Boron	Although boron may be toxic to humans and animals in high concentrations, there appears to be so little likelihood of such concentrations being reached that boron is not considered a hazard. Boron is believed to be present in Washington waters in only trace amounts.
Cadmium	The Dept. of Health, Education and Welfare, Public Health Service, Drinking Water Standards, imposes a mandatory limit on cadmium of 0.01 mg/l, on the basis of its toxicity to humans. Cadmium appears to be somewhat cumulative in the body.
Chromium	Chromium does not appear to be cumulative in the body. The U.S.P.H.S. limit is derived partially from the fact that 0.05 mg/l is about the lower limit of detectability of hexavalent chromium. Published information indicates that much larger concentrations are without adverse effects upon humans, and it is probable that the U.S.P.H.S. limit of 0.05 mg/l is extremely conservative. Chromium appears toxic to plants, but the level at which toxic effects begin to be discernible appears to be not less than 1.0 mg/l.

	Limits W.Q.C.	
Barium	Fresh Water	Fish
Goal*	0.01 mg/l	WQC suggests a limit of 5.0 mg/l is to protect fish and aquatic life from toxic effects.
Standard**	0.05 mg/l	
	Salt Water	
Goal	0.05 mg/l	
Standard	0.06 mg/l	
Boron	Fresh Water	
Goal	0.1 mg/l	
Standard	0.3 mg/l	
	Salt Water	
Goal	4.7 mg/l	
Standard	5.5 mg/l	
Cadmium	Fresh Water	
Goal	0.0005 mg/l	Fish appear to be quite sensitive to cadmium. In addition there appears to be a synergistic effect between cadmium and other metals, notably zinc. The lowest concentration indicated as being lethal to fish is equal to the U.S.P.H.S. limit of 0.01 mg/l. Salmon fry are reported to have been killed by 0.03 mg/l of cadmium together with 0.15 mg/l of zinc.
Standard	0.001 mg/l	
	Salt Water	
Goal	0.00011 mg/l	
Standard	0.00013 mg/l	
Chromium	Fresh Water	
Goal	Trace	Fish are less sensitive to chromium than are other organisms in the aquatic food chain. Concentrations of 0.016 mg/l and less appear toxic to organisms such as Daphnia magna, although the evidence is not unanimous on this point.
Standard	0.01 mg/l	
	Salt Water	
Goal	0.00005 mg/l	
Standard	0.00006 mg/l	

* See last page
** of table.

Remarks

Copper	The U.S.P. H.S. Drinking Water Standards recommended limit on copper is 1.0 mg/1. Copper is essential to plant life, but toxic when present in excess. The permissible range appears to lie below about 0.1 mg/1 for the most sensitive macroscopic plants. Threshold toxic limits of copper to animals appear to be substantially higher than the limit proposed for human use. Copper sulfate is widely used as a cheap and effective algicide; however, in hard water the margin between the dosage required as an effective algicide and the toxic level for fish is very narrow, and may result in fish kills. Marine biota are sensitive to copper. Oyster larvae require some copper (0.05-0.06 mg/1), but toxic effects begin to occur between 0.1 and 0.5 mg/1.
Iron	Stock and wildlife require some iron as do humans. There is no evidence to indicate that the toxicity threshold for animals is substantially lower than for humans. Irrigated agriculture is relatively unaffected by iron. Some iron appears to be beneficial to certain plants.
Lead	The U.S.P.H.S. Drinking Water Standards mandatory limit on lead concentration is 0.05 mg/1. This limit is based on the toxicity of lead, enhanced by its tendency to accumulate in the body. There is some evidence that lead is injurious to plants, but the threshold concentrations appear to be well above the U.S.P.H.S. Drinking Water Standards limit. Animals are sensitive to lead poisoning, as are humans, and apparently to about the same extent. Aquatic life also is susceptible to toxic effects from lead, although the mechanism by which the damage occurs may be different.

	Limits W.Q.C.	Fish
Copper		
Fresh Water		The effects of copper on fish appear to be magnified enormously by symbiotic association with zinc, cadmium, phosphate, chlorine, mercury and other materials. Concentrations of copper as low as 0.015 mg/l have been reported as toxic. The effect of copper is pronounced in soft water, possibly because copper carbonate precipitates from hard water and thus limits the concentration of copper in solution. Other aquatic organisms of importance to the food chain of fish are quite sensitive to copper. The maximum concentration of copper sulfate for trout is 0.014; carp 0.30, and gold fish 0.50.
Goal	0.02 mg/l	
Standard	0.05 mg/l above natural background	
Salt Water		
Goal	Less than 0.05 mg/l	
Standard	Less than 0.06 mg/l	
Iron		
Fresh Water		Fish may be adversely affected by dissolved iron, although the amount of iron in solution (ferrous iron) will be extremely small in well-aerated streams, i.e., those capable of supporting fish. There is some evidence that concentrations as low as 0.2 mg/l of ferrous iron may be deleterious, but some fish are known to thrive at higher concentrations.
Goal	0.0 mg/l) Total iron above natural content	
Standard	0.1 mg/l)	
Salt Water		
Goal	0.1 mg/l	
Standard	0.2 mg/l	
Lead		
Fresh Water		As in the case of certain other toxics, lead appears more toxic to fish life in soft than in hard water. Reduction of the oxygen saturation percentage appears to accentuate the effect of lead somewhat. Toxic effects from lead have been reported in fish at concentrations as low as 0.01 mg/l, although other tests have shown absence of toxic effects at concentrations as high as 4.0 mg/l.
Goal	Limit of detectability	
Standard	0.02 mg/l	
Salt Water		
Goal	0.00003 mg/l	
Standard	0.004 mg/l	

Remarks

Manganese

The U.S.P.H.S. Drinking Water Standards recommended limit on manganese of 0.05 mg/l is based on esthetic and economic as well as physiological considerations. The physiological hazards from excessive manganese are of dubious nature and occur at uncertain threshold concentration values, but it is apparent that 0.05 mg/l is substantially below any toxicity threshold.

Excessive concentrations of manganese may be harmful to plants, but the threshold levels of damage appear substantially higher than the Drinking Water Standards limit.

Animals appear to be unaffected by manganese at concentrations substantially higher than the U.S.P.H.S. limit.

Potassium

Within the limits imposed by commonly accepted standards, potassium has a negligible effect on most beneficial uses of water.

Some potassium is essential to plant nourishment, and it is commonly used as an ingredient (K_2O) in fertilizers to stimulate plankton growth in ponds. The range of concentration for this use is on the order of 0-5 mg/l.

Selenium

The U.S.P.H.S Drinking Water Standards impose a mandatory limit on selenium of 0.01 mg/l, based on toxicity.

Plants can tolerate much more selenium than can humans. However, food crops will incorporate some selenium into the edible portions and selenium poisoning can result from eating the plants. This effect is not believed to be detectable when the concentration of selenium in irrigation water is below 0.01 mg/l.

Stock and wildlife are susceptible to selenium poisoning, the result being known as alkali disease or blind staggers. This can result from ingestion of feed grown on selenium-rich soil, or from selenium-bearing water. It is believed that cattle can tolerate 0.4 to 0.5 mg/l without showing toxic effects, and this probably represents the order of magnitude of tolerance of other animals.

Silver

The U.S.P.H.S. Drinking Water Standards mandatory limit on silver is 0.05 mg/l. This limit is based primarily on the cosmetic effect of silver excessive ingestion resulting in a permanent discoloration of the skin and eyes. From the effects of silver on humans, it would be expected that levels safe for human consumption would be entirely safe for terrestrial animals.

	Limits	Fish
Manganese	W.Q.C.	
Fresh Water		
Goal	Trace	Fish appear to have some tolerance for manganese and at the limit of 0.05 mg/l it probably is not detrimental to them.
Standard	0.01 mg/l total Mn	
Salt Water		
Goal	0.002 mg/l	
Standard	0.04 mg/l	
Potassium		
Fresh Water		
Goal	2.5 mg/l	Adverse effects upon fish are reported at potassium concentrations on the order of 50 mg/l, especially in soft water and water low in total salt content.
Standard	5.0 mg/l	
Salt Water		
Goal	380 mg/l	
Standard	450 mg/l	
Selenium		
Fresh Water		
Goal	Limit of detectability	Fish appear to be somewhat more sensitive to selenium than are humans. Quantitative data are scarce, but it would appear that the conservative limit established by the U.S.P.H.S. Drinking Water Standards for human consumption is probably acceptable for most, if not all, fish. Fish apparently concentrate selenium in their livers, as a result of ingestion of selenium which enters the food chain at the plankton level.
Standard	0.002 mg/l	
Salt Water		
Goal	0.004 mg/l	
Standard	0.005 mg/l	
Silver		
Fresh Water		
Goal	Limit of detectability	Fish are quite sensitive to silver, lethal effects having been observed at concentrations as low as 0.003 mg/l. Plankton appear to be somewhat less sensitive than fish, but the difference is slight and, from the limited data available, may be more apparent than real.
Standard	0.003 mg/l	
Salt Water		
Goal	0.0003 mg/l	
Standard	0.0004 mg/l	

Remarks

Sodium

Because sodium is a waste product of many beneficial uses of water and has little adverse effect upon water in limited amounts, the use of a river to carry sodium is of less importance than other additives.

Sodium, like several other solutes in water, may indicate the presence of sewage or agricultural drainage. It is a conservative pollutant because most sodium salts are highly soluble and hence no removal occurs in either water treatment or sewage treatment processes. Where the natural sodium load is small the sodium concentration can serve as a pollution index.

Zinc

The U.S.P.H.S. Drinking Water Standards recommended limit on zinc of 5.0 mg/l is based on esthetic effects. Zinc is essential to human nutrition and, while toxic in large amounts, is not adverse physiologically within the range of esthetic acceptability.

Zinc is essential to plant nutrition and, as with humans, can be toxic if present to excess. Values as low as 3 mg/l have been observed to be harmful.

The adverse effects of zinc to stock and wildlife are comparable to the effects on humans. Some synergistic effects appear to occur when zinc is present in combination with selenium, copper and possibly other materials.

Ammonia nitrogen

The U.S.P.H.S. Drinking Water Standards lists no limit for ammonia nitrogen, although the WHO European Drinking Water Standards set a recommended limit of 0.5 mg/l as NH_4. However, any such limits are based on the presence of ammonia being an indicator of organic pollution rather than on its toxicity.

Because of its potentially toxic effects on fish and because of the fact that it indicates organic pollution of water and serves as a nutrient for nuisance growth, the following limits are proposed for ammonia nitrogen.

Cyanide

The U.S.P.H.S. Drinking Water Standards contain both recommended (0.01 mg/l) and the mandatory (0.2 mg/l) limits for cyanide. These limits are based on toxicity, but the derivation of them appears to be founded more on toxicity to fish than to humans.

Stock and wildlife appear no more sensitive toward cyanide than do humans.

	Limits	Fish
Sodium	W.Q.C.	
	Fresh Water	
	Goal: 10 mg/l over natural concentration	
	Standard: 35 mg/l over natural concentration	
	Salt Water	
	Goal: 10,500 mg/l	
	Standard: 12,500 mg/l	
Zinc		
	Fresh Water	
	Goal: Limit of detectability	Fish are strongly affected by zinc. Concentrations as low as 0.01 mg/l have been observed to be lethal. The toxicity of zinc is greatest in soft water. Shellfish appear less sensitive to zinc than do swimmers, but are able to concentrate zinc from large amounts of water, possibly by ingestion of plankton which concentrate zinc from the water.
	Standard: Limit of detectability	
	Salt Water	
	Goal: 0.01 mg/l	
	Standard: 0.012 mg/l	
Ammonia nitrogen		
	Fresh Water	
	Goal: 0.3 mg/l	Fish appear to be more affected by undissociated ammonium hydroxide (NH_4OH) than by the ammonium ion (NH_4^+). Thus the toxicity of a given concentration of ammonia to fish increases with increasing pH. As with most other toxicants, the effects of ammonia are increased at low oxygen concentrations. The concentrations of ammonia at which fish suffer distress are variously reported at from 0.3 mg/l upward, but the majority of values indicated lie above 1.0 mg/l.
	Standard: 0.5 mg/l	
	Salt Water	
	Goal: 0.0025 mg/l	
	Standard: 0.003 mg/l	
Cyanide		
	Fresh Water	
	Goal: 0.005 mg/l	Fish appear quite sensitive to cyanide, more so than do lower forms of aquatic life. The lowest concentration at which toxic effects are noted is 0.05 mg/l (trout); but 0.02 mg/l were survived by trout for a period of 27 days. In view of the other data cited, the U.S.P.H.S. recommended limit (0.01 mg/l) is probably a reasonable limit for safety to all aquatic life.
	Standard: 0.01 mg/l	
	Salt Water	
	Goal: None detectable	
	Standard: 0.01 mg/l	

Remarks

Fluoride

The U.S.P.H.S. Drinking Water Standards mandatory fluoride limit varies from 0.6 to 1.7 mg/l, depending in part on the average air temperature and hence the amount of water consumed per day. For drinking purposes, fluoride is generally considered to be a valuable addition to water. Too much fluoride, however, leads to mottled tooth enamel and in high doses it can be toxic.

The threshold concentration of fluoride in water at which damage to irrigated crops begins to occur appears to lie between 10 and 100 mg/l.

1.0 mg/l of fluoride seems to have no deleterious effect on livestock.

Nitrate

A major problem with nitrate is eutrophication. Blooms of algae and other aquatic plants have severe economic and esthetic effects, affect fish and other aquatic life, including the killing of fish when a bloom dies and deoxygenation occurs, and cause serious problems in water treatment for domestic use. Blooms of algae and massive growths of other aquatic plants are possible when the nitrate content in the presence of other essential nutrients is about 0.5 mg/l or more.

Based on considerations of eutrophication alone, the following limits for nitrate are used.

Nitrogen

Water will absorb only a certain amount of nitrogen from the air at atmospheric pressure and at a given temperature. When the air is under pressure the water becomes supersaturated with dissolved gases (oxygen, nitrogen, and carbon dioxide). Excess nitrogen often occurs in spring or well water. It also may result from air entering the intake side of a water pump, or from air entering the intake of a gravity pipe line and being forced into solution by the gravity head on the line. Sudden warming of water may cause supersaturation.

It is not always easy to remove immediately all excess nitrogen from a water supply. This can be done by vigorously breaking up the water so that excess gas is released to the atmosphere.

	Limits	Fish
Fluoride W.Q.C.		
Fresh Water		Fish and other aquatic life appear to be affected by fluoride in much the same way as do land animals, and in approximately the same concentration ranges. The lowest concentration at which adverse effects are reported (slower and poorer hatching) (species not identified) is 1.5 mg/1.
Goal	0.5 mg/1	
Salt Water		
Goal	1.3 mg/1	
Standard	1.5 mg/1	
Nitrate		
Fresh Water		Fish appear relatively indifferent to nitrate, although the associated nitrite can be toxic to them. Nitrite is an intermediate compound between nitrate and the more reduced forms of nitrogen and seldom persists long as nitrate, being readily oxidized or reduced.
Goal	0.1 mg/1 above natural content	
Standard	0.4 mg/1 above natural content	
Nitrogen		
Salt Water		
Goal	Less than 0.6 mg/1	
Standard	0.6 mg/1	
Saturation		Of the excess gases in supersaturated water, nitrogen is least tolerated by fish. Nitrogen is absorbed into the blood stream, causing gas bubbles which result in death of the fish. Fry will develop a visible gas bubble in the body cavity.
		The percent of nitrogen saturation in water which is detrimental or lethal to salmon is as follows:--
		Fry--103%
		Fingerlings and yearlings--113% (lethal) --105-112% (eye damage and blindness)
		Adult salmon----------118% (eye damage)

Remarks

Phosphates	Phosphates are of concern primarily because of the fact that phosphorus, being a fertilizer, frequently present naturally only in limited amounts, can contribute to the growth of aquatic organisms, especially when water is impounded. Such growths can reach severe nuisance proportions even with very small phosphate concentrations. Heavy algal blooms have been observed in lakes when the phosphate concentration exceeds 0.03 mg/l.
Radio-activity	The effects of radioactivity in surface waters are extremly complex. However, there appears to be no safe threshold below which no damage to man or other living organisms will result from exposure to ionizing radiation. Any exposure is detrimental. It appears that concentration is by far the most serious effect. Radionuclides in the aquatic or marine environment may affect organisms by (a) direct radiation from the water or accumulated bottom sediments, (b) absorption of radioactive material on the body surfaces, (c) absorption through cell membranes of soluble substances, and (d) ingestion or radionuclides along with food and water. For herbivores and carnivores, including fish, ingestion of radionuclides concentrated by lower forms of life appears to be the major route of accumulation.
Surfactants	Surfactants are also known as surface-acting agents or detergents. The surfactant formerly in widespread use in household washing products was ABS, which presented a considerable problem. The surfactant used almost exclusively since 1965 is LAS, which is more readily biodegradable. The U.S.P.H.S. Drinking Water Standards recommended limit for ABS is 0.5 mg/l. The substitution of terms and retention of the former limits would appear reasonable for LAS.
Hydrogen sulfide (H_2S)	The sources of H_2S in water include natural processes of decomposition, sewage and industrial wastes, such as those from tanneries, paper mills, textile mills, chemical plants, and gas-manufacturing works. It is a major component of Kraft mill waste liquors, which is the principal source of this type of pollution in the Pacific Northwest. In the presence of certain sulfur-utilizing bacteria, sulfides and H_2S can be oxidized to colloidal sulfur, and these bacteria or their deposits may be considered as corollary pollutants.

	Limits	Fish
Phosphates	W.Q.C. Fresh Water Goal 0.03 mg/l Standard 0.15 mg/l Salt Water Goal 0.3 mg/l Standard 0.4 mg/l	Phosphates are of no direct toxic significance to fish. However, like nitrogen compounds, they present a eutrophication problem. When a plant bloom dies and deoxygenation occurs fish kills may result.
Radio-activity	Fresh and Salt Water Goal: No induced radioactivity U.S.P.H.S. Drinking Water Standards	Exposure to humans and fishes can be increased profoundly by consumption of food products such as shellfish or plankton, some of which concentrate radionuclides within themselves from large amounts of water. The present radioactivity in the Columbia River poses no direct somatic hazard toward fish.
Surfactants	Fresh and Salt Water Goal: Trace Standard: 0.10 mg/l	Fish and aquatic organisms are subject to toxic effects of surfactants; the concentration necessary to produce such effects appear to be one or more orders of magnitude greater than the U.S.P.H.S. Drinking Water Standards (0.5 mg/1), for the most part.
Hydrogen sulfide	The maximum concentration of H_2S tolerated by fish is within the range of 0.3-1.0 mg/1. Chinook salmon have survived in tests at a H_2S concentration of 0.3 mg/1, cutthroat trout at 0.5 mg/1, and silver salmon at 0.7 mg/1.	H_2S at a concentration of 10 mg/1 has been reported as toxic to a salmon and trout in 24 hours. At a concentration of 10.0 mg/1 it is reported as toxic to trout in 15 minutes.

	Remarks
Methanethiol	This gas is also known as methyl mercaptan, and occurs in Kraft pulp mill wastes. At certain concentrations and water temperatures it can be highly toxic to fish.
Methyl ethyl Ketone	This is a widely used liquid solvent in industry. It is used in the manufacture of synthetic resins, and is highly soluble in water. Bio-assays indicate that at certain concentrations it is toxic to fish.
Phenol and Phenolic Compounds	Phenolic wastes arise from the distillation of wood, from chemical plants, gas works, oil refineries and other industrial operations, as well as from human and animal refuse. Phenol is commonly used in the manufacture of synthetic resins and other industrial compounds. It is highly soluble in water. Phenol is biologically dissimilated in a concentration of 1.0 mg/l at 20°C. in 1 to 7 days under aerobic conditions. At 4°C. (39.2 F) complete dissimilation required 5-19 days. Under anaerobic conditions dissimilation occurs at a slower rate. The U.S.P.H.S. Drinking Water Standards recommended limit of 0.001 mg/l for phenol is primarily an esthetic limit, based upon the undesirable taste imparted to water by chlorination when even minute amounts of phenol are present.
Mercury	Mercury has been found to be inert, but enters the aquatic food chain and becomes concentrated in fish and is transferred from prey to predator.

Methanethiol	Limits W.Q.C.	Fish		
Water Temp. of test, °C.		Chinook Salmon 15.5-19.5	Silver Salmon 12-18	Ct. Trout 9-15
Minimum concentration for complete kill, mg/l.		0.9	1.75	1.2
Maximum concentration for no kill, mg/l.		0.5	0.7	0.9

Methyl ethyl Ketone			
Water temp. of test, °C.	Bluegill 20.0	Gambusia 20.0	
Fish adversely affected, 24 and 48 hours, mg/l	3,380		
TLm, 24 and 48 hours, mg/l	5,640		
TLm, 24, 48, and 96 hours, mg/l		5,600	

Phenol and Phenolic Compounds

Fresh Water	
Goal	Limit of detectability
Standard	0.0005 mg/l

Salt Water	
Goal	0.04 mg/l
Standard	0.05 mg/l

Fish are reported to have been harmed by phenol concentrations as low as 0.079 mg/l. However, the taste of fish may be affected by subtoxic levels of phenol in the water.

The reported lethal concentrations of phenolic compounds for fish vary widely not only because of the common variables such as species, temperature, time of contact, dissolved oxygen and mineral quality of water, but also because of synergistic and antagonistic effects of other substances in the water. Many phenolic substances are more toxic than pure phenol.

Mercury

Fresh Water	
Goal	Limit of detectability
Standard (interim)	0.05 mg/l

At this time mercury kills have not been reported.

	Remarks
Miscellaneous	There are a large number of miscellaneous toxicants that may be present in industrial effluents. These would include mercaptans, sulfides, resins, chlorine and residues from metal processing. These are also contained in pulp mill effluents. They can be readily reduced to near zero levels by effective effluent treatment. Because of their adverse effect and because they are amenable to removal from waste streams, concentrations of these effluents should not exceed the limits of reliable analytical detectability.

Miscellaneous	Limits W.Q.C.	
	Fresh Water	
Goal	None detectable	In addition to their direct toxic effects on fish, which may be considerable, some of these effluent products, as spent sulfite liquor, may exert indirect harmful effects such as deoxygenation and eutrophication.
Standard	None detectable	
	Salt Water	
Goal	None detectable	
Standard	None detectable	

* Goal, the more restrictive of the quality criteria, is defined as the desirable value of water quality parameters, which may or may not be practicable at the present time.

** Standard, the less restrictive of the quality criteria, is proposed as an objective to be achieved or maintained immediately or within a short period of time.

REFERENCES

McKee, Jack Edward, and Harold W. Wolf, "Water quality criteria." California State Water Quality Control Board, Publication 3-A. Second edition. Sacramento, California. 1963.

Sylvester, Robert O., and Carl A. Rambow, "Water quality of the State of Washington." Volume IV of "An Initial Study of the Water Resources of the State of Washington." Washington State Water Research Center, Pullman, Washington. 1967.

Jones, J. R. Ericksen, "Fish and River Pollution." Butterworths, London. 1964.

WATER CHEMISTRY

(all readings in mg/liter)

South central Alaska streams

	Copper River Nr. Chitna	Power Creek Nr. Cordova	Eyak Lake S4 Nr. Cordova	Gulkana River at Sourdough	Little Tosina River Nr. Tosina
Acidity	7/16/75 8.2	6/6/75	6/6/75 .5'-7.5	6.8 July 7.7 May 6.8 Sept. 8.0	Jan. 6.6 April 7.6 July 7.0
Alkalinity (total hardness)	65	17	.5'-17	May 34	June 35
Ammonia				March 0.03 May 0.02 July 0.03 Sept. 0.00	March 0.02 April 0.02 June 0.78 July 0.03 Sept. 0.00
Cadmium (soft water)	< 0.010	0.000	.5'-0.000		
Cadmium (hard water)					
Chromium	0.070	0.000	.5'-0.000		
Copper	0.210	0.000	.5'-0.000		
Zinc	0.180	0.000	.5'-0.000		
Hydrogen sulfide					
Lead	< 0.100	0.000	.5'-0.000		
Mercury (organic or inorganic)	0.0004				
Nitrogen				March 0.31 May 0.74 July 0.44 Sept. 0.59	March 0.49 April 0.59 June 1.2 July 0.22 Sept. 0.15
Polychlorinated biphenyls (PCB's)					
Total suspended and settleable solids	3230			March 9 May 274 July 25 Sept. 5	March 4 April 11 May 39 June 19 July 10 Sept. 4
Iron	62.000	0.010	.5'-0.030	May 0.360	June 0.120
NO_3 Nitrate	Dissolved Nitrate & Nitrite 0.05	Dissolved Nitrate & Nitrite 0.05	Dissolved Nitrate & Nitrite .5'-0.01	Nitrate & Nitrite March 0.17 June 0.02 July 0.01 Sept. 0.05	Nitrate & Nitrite March 0.09 April 0.08 June 0.25 July 0.01 Sept. 0.03
2-4 D					
Malathion					

(all readings in mg/liter)

South central Alaska streams

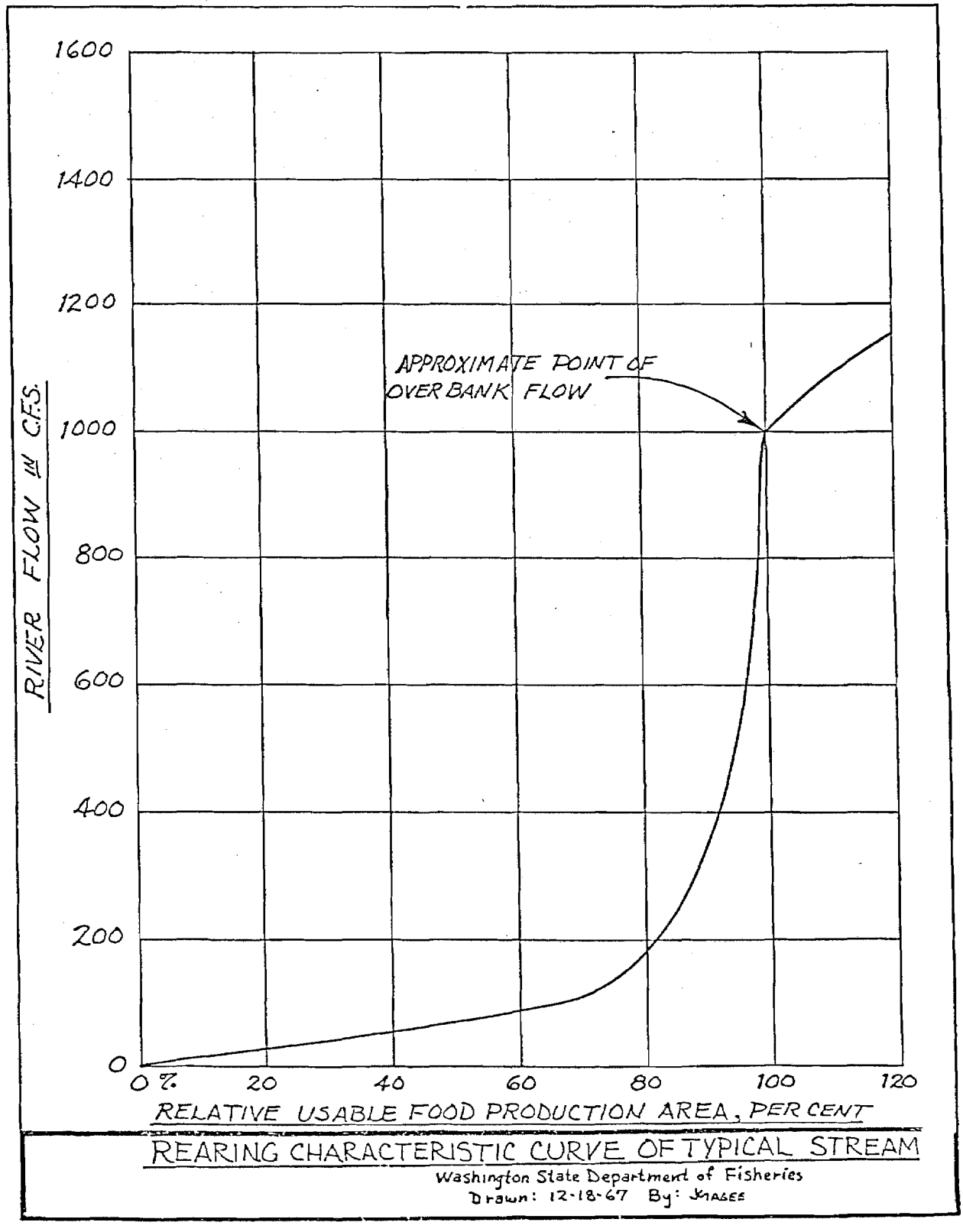
	Dick Creek Nr. Cordova	South Fork Campbell Creek at Canyon Mouth Nr. Anchorage	North Fork Campbell Creek Nr. Anchorage	Campbell Creek Nr. Spenard	Meals Lake at Cordova
Acidity	Aug. 6.0 Sept. 6.8	Sept. 25, 1975	Sept. 25 6.4	Sept. 25 6.4	June
Alkalinity (total hardness)					" 11
Ammonia	Sept. 0.00		" 0.03	" 0.03	
Cadmium (soft water)					" 0.000
Cadmium (hard water)		" 0.000	" 0.000	" 0.000	
Chromium					" 0.000
Copper	Aug. < 0.010 Sept. < 0.010				" 0.001
Zinc	Aug. 0.010 Sept. 0.020				" 0.000
Hydrogen sulfide					
Lead		" 0.002	" 0.002	" 0.005	" 0.001
Mercury (organic or inorganic)	Sept. 0.000				
Nitrogen	Aug. 0.33 Sept. 0.75				
Polychlorinated biphenyls (PCB's)					
Total suspended and settleable solids	Aug. 10 Sept. 2				
Iron	Aug. 0.320 Sept. 0.060		" 1.900	" 1.100	0.050
NO_3 Nitrate	Nitrate & Nitrite Aug. 0.03 Sept. 0.05				Dissolved Nitrate & Nitrite June 0.01
2-4 D					
Malathion		" 0.00000	" 0.00000	" 0.00000	

OXYGEN CONCENTRATES AT VARIOUS TEMPERATURES IN FRESHWATER

Temperature °F	Temperature °C	By weight mg/l ppm	By weight oz/ft^3	By weight oz/gal	By volume cc/l	By volume ft^3/ft^3	By volume ft^3/gal
39	3.9	13.1	.0131	.00175	9.24	.00924	.00124
40	4.4	13.0	.0130	.00174	9.09	.00909	.00122
41	5.0	12.8	.0128	.00171	8.94	.00894	.00120
42	5.5	12.6	.0126	.00168	8.84	.00884	.00118
43	6.1	12.4	.0124	.00166	8.74	.00874	.00117
44	6.6	12.2	.0122	.00163	8.59	.00859	.00115
45	7.2	12.1	.0121	.00162	8.44	.00844	.00113
46	7.7	11.9	.0119	.00159	8.34	.00834	.00111
47	8.3	11.8	.0118	.00158	8.24	.00824	.00110
48	8.9	11.6	.0116	.00155	8.14	.00814	.00109
49	9.4	11.5	.0115	.00154	8.04	.00804	.00107
50	10.0	11.3	.0113	.00151	7.94	.00794	.00106
51	10.5	11.2	.0112	.00150	7.84	.00784	.00105
52	11.1	11.0	.0110	.00147	7.74	.00774	.00103
53	11.7	10.9	.0109	.00146	7.64	.00764	.00102
54	12.2	10.8	.0108	.00144	7.54	.00754	.00101
55	12.8	10.6	.0106	.00142	7.44	.00744	.00099
56	13.3	10.5	.0105	.00140	7.34	.00734	.00098
57	13.9	10.3	.0103	.00138	7.29	.00729	.00097
58	14.4	10.2	.0102	.00136	7.19	.00719	.00096
59	15.0	10.1	.0101	.00135	7.09	.00709	.00095
60	15.5	10.0	.0100	.00134	7.04	.00704	.00094
61	16.1	9.9	.0099	.00132	6.99	.00699	.00093
65	18.3	9.4	.0094	.00126	6.59	.00659	.00088

METHODS OF MEASURING FOOD-PRODUCING AREAS

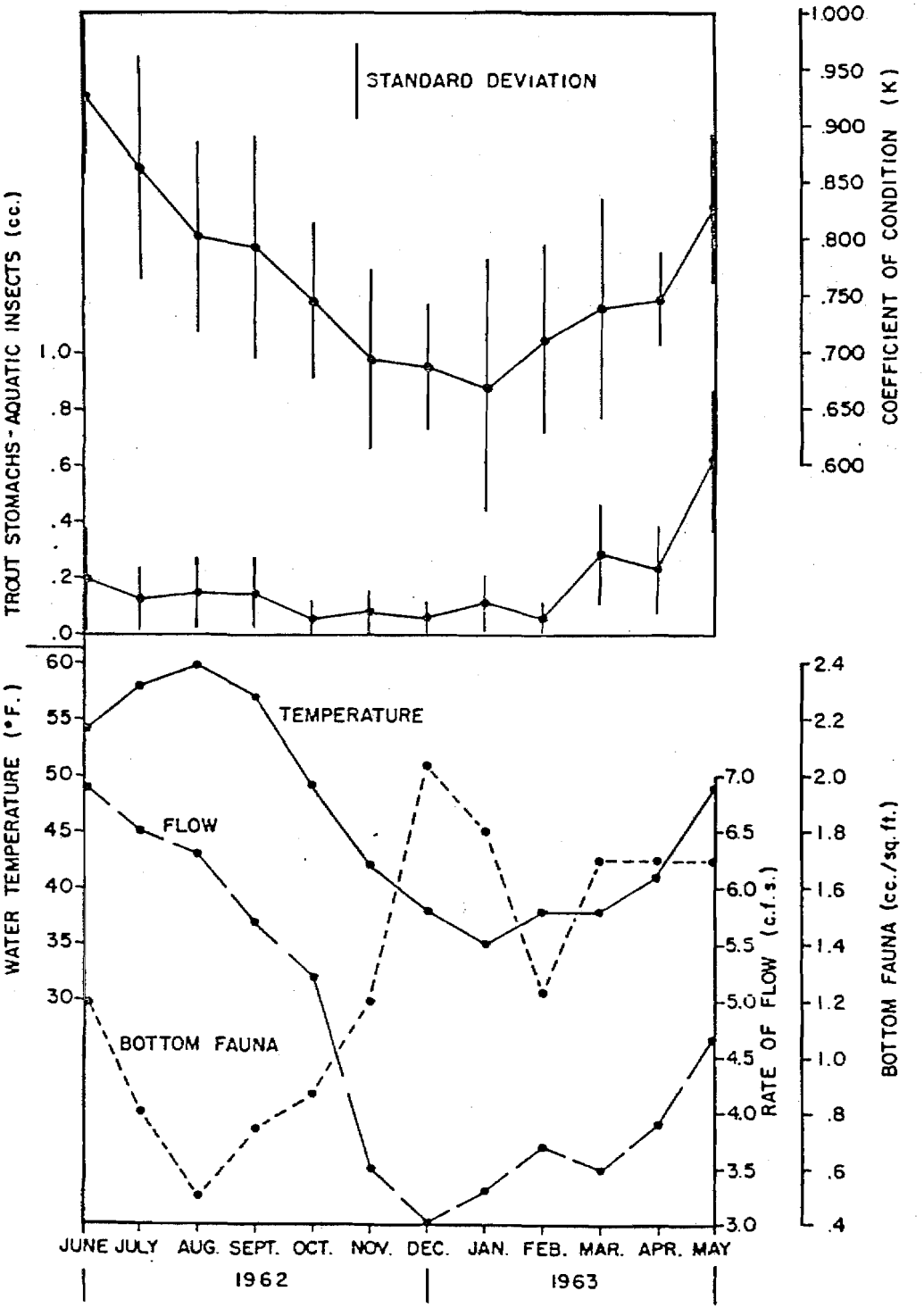
Figure 1



REARING CHARACTERISTIC CURVE OF TYPICAL STREAM

Washington State Department of Fisheries
Drawn: 12-18-67 By: JHAGEE

Figure 2



-Condition of the trout (K) in relation to utilization and abundance of bottom organisms, rate of flow and stream temperature.

RELATIVE SWIMMING SPEEDS OF FISH

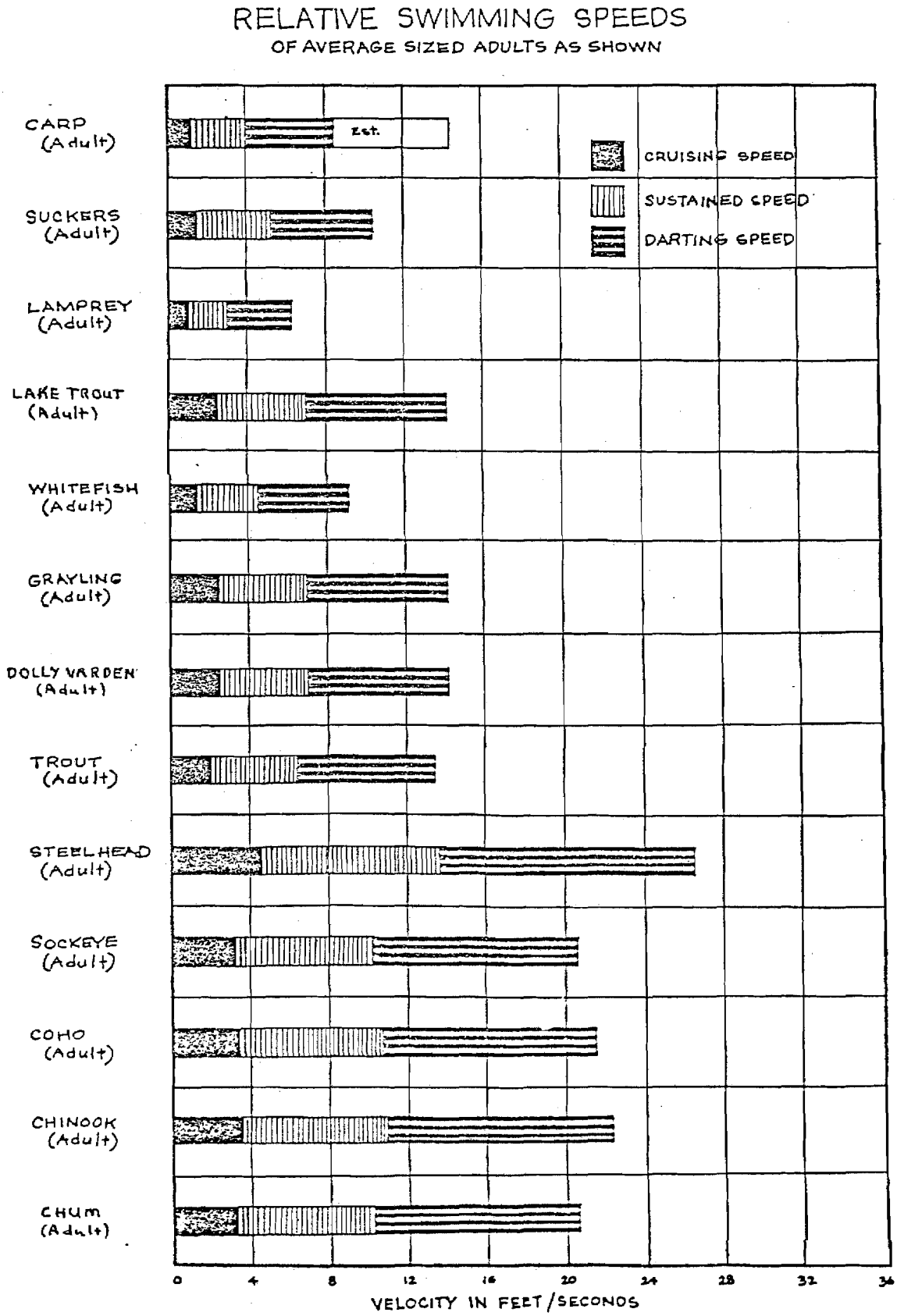
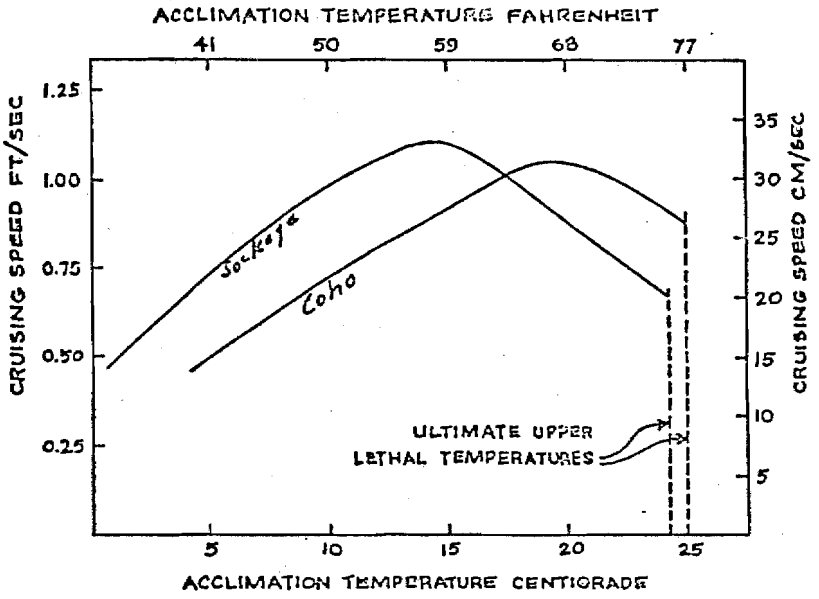


Figure 1



MAXIMUM SUSTAINED CRUISING SPEED OF SOCKEYE AND COHO UNDERYEARLINGS IN RELATION TO TEMPERATURE

FROM DRETT, 1958

REFERENCES

Black, Edgar C., "Energy stores and metabolism in relation to muscular activity in fishes." In H. R. Macmillan Lectures in Fisheries, "The Investigation of Fish-Power Problems," pp. 51-67. Symposium held at the University of British Columbia, April 29-30, 1957, edited by P. A. Larkin. University of British Columbia, Institute of Fisheries, Vancouver. 1958.

Black, Edgar C., Anne Robertson Connor, Kwok-Cheung Lam, and Wing-gay Chiu, "Changes in glycogen, pyruvate and lactate in rainbow trout (Salmo gairdneri) during and following muscular activity." Fisheries Research Board of Canada, Journal, 19(3): 409-436. May, 1962.

The Progressive Fish-Culturist, 27(3):157. July, 1965. (News note on swimming speeds.)

Gray, James, "How fishes swim." Scientific American, 197(2):48-65. August, 1957.

Davis, Gerald E., Jack Foster, Charles E. Warren, and Peter Doudoroff, "The influence of oxygen concentration on the swimming performance of juvenile Pacific salmon at various temperatures." Transactions of the American Fisheries Society, 92(2):111-124. April, 1963.

MacKinnon, Dixon, and William S. Hoar, "Responses of coho and chum salmon fry to current." Fisheries Research Board of Canada, Journal, 10(8):523-538. November, 1953.

Williams, I. V., "Implication of water quality and salinity in the survival of Fraser River sockeye smolts." International Pacific Salmon Fisheries Commission, Progress Report No. 22. New Westminster, B. C. 1969.

Idler, D. R., and W. A. Clemens, "The energy expenditures of Fraser River sockeye salmon during the spawning migration to Chilko and Stuart Lakes." International Pacific Salmon Fisheries Commission, Progress Report No. 6. New Westminster, B. C. 1959.

Fields, Paul E., Ronald J. Adkins, and Gary L. Finger, "The swimming ability of immature silver salmon (Oncorhynchus kisutch) measured in an experimental flume." University of Washington, School of Fisheries, Technical Report No. 9. Seattle. 1954.

Paulik, Gerald J., and Allan C. DeLacy, "Changes in the swimming ability of Columbia River sockeye salmon during upstream migration." College of Fisheries, Technical Report 46, University of Washington, Seattle. 1958.

Brett, J. R., M. Hollands, and D. F. Alderdice, "The effect of temperature on the cruising speed of young sockeye and coho salmon." Fisheries Research Board of Canada, Journal, 15(4):587-605. July, 1958.

Connor, Anne R., Carl H. Elling, Edgar C. Black, Gerald B. Collins, Joseph R. Gauley, and Edward Trevor-Smith, "Changes in glycogen and lactate levels in migrating salmonid fishes ascending experimental 'endless' fishways." Fisheries Research Board of Canada, Journal, 21(2):255-290. March, 1964.

Paulik, G. J., A. C. DeLacy, and E. F. Stacy, "The effect of rest on the swimming performance of fatigued adult silver salmon." School of Fisheries, Technical Report 31, University of Washington, Seattle. 1957.

Brett, J. R., "The relation of size to the rate of oxygen consumption and sustained swimming speed of sockeye salmon (Oncorhynchus nerka)." Fisheries Research Board of Canada, Journal, 22(6):1491-1501. November, 1965.

Paulik, G. J., and A. C. DeLacy, "Swimming abilities of upstream migrant silver salmon, sockeye salmon and steelhead at several water velocities." School of Fisheries, Technical Report 44, University of Washington, Seattle. 1957.

PACIFIC SALMON INCUBATION TIMES (Fahrenheit Degrees) AT 50°

Species	Average Temp. Units
Chinook	900
Coho	850
Sockeye	1300-1400
Chum	900
Pink	1050

$$\frac{\text{Temperature Units}}{\text{Average Water Temperature} - 32^{\circ}} = \text{Approximate Number of Days to Hatch}$$

(Temp below 40° F lethal prior to eyed stage)

Source: Donaldson, L. R. (Personal communication)

Species	Temperature Units to Hatching
Chinook	900
Coho	850
Sockeye	1200
Chum	950
Pink	1050

Source: Simon, R. C., 1963. Chromosome morphology and species evolution in the five North American species of Pacific salmon (Oncorhynchus). Journal of Morphology, Vol. 112(1): 77-97.

Sockeye Salmon

Temperature	Temperature Units to Hatching	Temperature Units to Swim Up Stage
34	450	682
36	734	1112
38	942	1428
40		
42	1115	1690
44		
46	1201	1820
48		
50	1254	1908
52		
54	1365	2068
56	1441	2184
58	1523	2308
60	1626	2464

Pink Salmon (Note: Pink salmon will not survive temperatures below 40° F prior to blastopore closure (Eyed Stage))

Temperature	Temperature Units to Hatching	Temperature Units to Swim Up Stage
40	1003	1520
42	1115	1690
44	1172	1776
46		
48	1309	1984
50		
54	1467	2222

Chum Salmon

Source: E. L. Brannon (Personal communication)

Species	Temperature Units to Hatching	Mean Length at Hatching (mm)
Sockeye	1345	22.50
Chum	974	25.24
Pink	1150	22.96

Sources: Withler, F. C. & R. B. Morley, 1970. Sex-related parental influences on early development of Pacific salmon. Journ. Fish. Res. Bd. Canada, 27(12): 2197-2214.

SUBTASK 7.11
WILDLIFE ECOLOGY ANALYSIS

INTRODUCTION

Following are detailed scope statements submitted to expand upon the summaries presented in the main volume of this plan of study. The detailed scope statements are arranged in a similar fashion as the summary statements and include big game, furbearers, and birds and non-game mammals.

The general philosophy upon which the approach to the wildlife ecology program was developed is that the wildlife community represents a system; this system is connected by means of a complex variety of interrelationships, and is influenced by the nature and distribution of plant communities. In order to assess the impact of the Susitna Project on any one component of the system it is necessary to have at hand baseline data on all members of the system. Therefore, the following plan of study provides for the collection of data on each major group of wildlife species, and although emphasis is placed on some species, such as big game, no group is ignored or covered in a cursory fashion. To take other than this approach would result in an inadequate effort and reduce our ability to make accurate impact predictions and recommend meaningful mitigation measures on any one component of the system.

BIG GAME

INTRODUCTION

Although TES proposes, in general, to approach the impact evaluation of the wildlife resources of the upper Susitna River basin by considering all components of the faunal community, we recognize, and agree with, the fact that big game species have a unique importance in this case. There is little doubt that to the people of Alaska, and to the major resource agencies, big game is a very valuable resource and is thus worthy of major consideration in the impact analysis for the Susitna Project. Therefore, much consideration was given to the best manner of addressing this issue during the development of our plan of study(POS).

During the several years that preceded the development of this POS many recommendations have been made concerning what steps, and levels of effort, should be employed to adequately deal with the big game impact issue. After reviewing many of these recommendations, TES believes that the program (Footnote 1), proposed by the Alaska Department of Fish and Game (ADF&G) was best suited to the needs of this study. We agree with the objectives outlined in that proposal and the methods needed to accomplish the objectives, as well as the duration of the studies required to collect and analyze the data.

There are two portions of the ADF&G proposal which we feel were not adequately addressed and are not in accordance with our desire to investigate the total faunal community. The first area of disagreement is the concern for furbearers and small game. We feel that an inadequate effort was proposed by ADF&G in regards to these groups; therefore, TES has proposed a considerably greater effort than that indicated in the ADF&G proposal. Details of our proposal concerning these groups can be found in the sections entitled "Furbearers" and "Birds and Non-game Mammals". The section of our proposal on Birds and Non-game Mammals also demonstrates a much greater effort in regards to non-game species than the cursory effort proposed by ADF&G.

We have, therefore, removed those items from the ADF&G proposal and suggest that the ADF&G proposal in regards to moose, caribou, bears, wolves, wolverines, and Dall sheep be implemented by the Alaska Power Authority as the best approach to addressing the big game situation. One change is recommended, however, in regards to moose. The ADF&G proposal included a section dealing with mitigation measures for moose. We feel that it is premature to move forward on this issue until more information is gathered in the field. Therefore, we recommend that ADF&G reevaluate the moose mitigation program and associated cost estimates following 2 years of data collection. As stated in the main proposal volume,

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1. Issued as Appendix II to the March 1978 report by K. P. Taylor and W. B. Ballard, (Moose Movements and Habitat Use along the Upper Susitna River - A Preliminary Study of Potential Impacts of the Devils Canyon Hydroelectric Project).

we recommend that the Alaska Power Authority contract directly with ADF&G to conduct the studies proposed in their March 1978 proposal, and designate TES to administer the technical aspects of the contract in order to maximize coordination with other portions of the wildlife ecology analysis

DATA COLLECTION

In accordance with the aforementioned recommendations, the following data collection procedures have been taken directly from the ADF&G proposal. These procedures adequately represent what TES feels should be done to secure the data necessary for an accurate impact analysis.

MOOSE

Habitat Analysis

A habitat type map of the proposed impoundment areas, all drainages flowing into the impoundments, access and transmission corridors and the downstream floodplain should be prepared during the first two years of the study. This map should be of sufficient detail to permit delineation of specific habitats favored by moose and must be accompanied by sufficient ground truth data to identify the distribution and abundance of moose browse species. In order to accomplish this it is essential that the principal investigators of moose studies work directly with the habitat mappers.

Studies of the effects of water table and influence of water level fluctuations on vegetation, particularly moose browse species, along the floodplain of the Susitna River should be initiated immediately. A map of areas where changes in flow caused by the dams will alter the vegetation, either through changes in soil moisture or by allowing plant succession to occur, should be prepared. Emphasis should be placed on areas of high moose use such as the lower Susitna River.

Detailed studies of vegetation in important moose wintering areas should be conducted to identify plant species used by moose and quantify their presence, use and trends. Study areas would be identified from data collected under the moose studies.

Schedule: 1980 - 1984.

Population Analysis

During 1977, 12 moose were radio collared and 14 others were collared with visually identifiable collars. These moose were tracked from March to December 1977. Under this study, tracking of those moose will be continued, to further delineate the ranges of that subpopulation.

Additional moose will be radio collared in drainages along the south side of the proposed impoundment area and in riparian habitats along the mainstem below Devils Canyon.

Each radio collared moose will be relocated regularly. For each relocation the exact location, habitat type, activity of the moose and association with other animals will be recorded.

A random stratified census and seasonal sex and age composition counts will be conducted on subpopulations most likely to be affected by the Susitna Hydropower Project. Concentrations of moose will be mapped throughout the area whenever the opportunity arises.

These data will be used to identify subpopulations using areas to be impacted, to determine the seasonal ranges and migration routes of each subpopulation and to estimate the size and composition of those subpopulations most likely to be impacted. Locations of moose will be overlayed on habitat maps to determine the degree of use of certain habitat types as well as specific habitats. This information will be analyzed by subpopulation, season, sex and age class and reproductive status. Areas likely to be altered by the project that are critical to a subpopulation will be identified and recommended for more detailed vegetation studies.

Schedule: 1980 - 1984.

CARIBOU

Caribou on both sides of the Susitna River will be radio collared during the breeding season. Monitoring flights will be made at a relatively low intensity (approximately monthly) throughout most of the year to determine if more than one population exists in the area and to determine seasonal ranges of each population identified. More intensive monitoring flights will be made during the periods of precalving and postcalving movements and winter shift to determine present migration routes and the timing of migration. It will be necessary to repeat this procedure for several years to determine variation among years.

Traditional migration routes will be determined by mapping trails and will be compared with present routes.

Potential alternative ranges will be identified and evaluated using the modified Hult Surlander method of range analysis. These ranges will be compared with Nelchina ranges that have been studied for a number of years.

Schedule: 1980 - 1984.

WOLVES

Two to four wolves will be radio collared in each pack whose territory is believed to include potential impoundment areas and construction sites. The numbers of wolves in each pack will be determined, each pack's territory will be delineated and the degree and nature of use of potential impact areas will be determined through repeated relocations and observation of activities. Specifically, all den sites, rendezvous sites and favored hunting

areas will be mapped. These data will be used to determine the degree of dependence of wolves on various areas that will be impacted by the Project.

Dependency on various prey species will be determined by scat analysis and observation of hunting behavior and kills. This information will be used in conjunction with data from the accompaning studies of prey species, particularly the moose study, to estimate indirect impacts on wolves caused by a reduction in prey availability.

Field activities and manpower for this study will be integrated with the moose study. Wolves frequently will be tagged and relocated at the same time as moose. Full funding of the moose study is required for the successful implementation of this study.

Schedule: 1980 - 1984.

BEARS

Bears will be radio collared in the project area. Movements in and around the area will be monitored. Den sites and concentration areas will be mapped.

Bear numbers will be estimated through marked/unmarked ratios observed during spring and fall composition counts and by recording all bears seen during tracking flights.

Field activities for this study will be closely integrated with those for the moose and wolf studies. Full funding of the moose study is required for the successful implementation of this study.

Schedule: 1980 - 1983.

WOLVERINE

A limited number of wolverines will be radio collared and tracked in conjunction with other telemetry studies in the area. Home ranges, movement patterns, and seasonal habitat use will be determined by systematic relocation of radio collared animals.

A systematic aerial survey of wolverines and their tracks will be made in conjunction with wolf studies to determine the distribution and numbers of wolverines using the area.

These data will be used to estimate the number of wolverines using the impoundment areas, determine the degree of dependence of certain wolverines on those areas and identify specific areas of importance to wolverines.

Schedule: 1980 - 1982.

DALL SHEEP

Aerial surveys will be conducted to determine the size of the sheep population and to delineate seasonal ranges.

Schedule: 1980 - 1982.

IMPACT ASSESSMENT

As stated in the main proposal volume, TES proposes to obtain the services of an individual, or group, outside of the Alaska Department of Fish and Game to perform an independent impact assessment on big game. Because the impact of the Susitna Project on big game is one of the major issues associated with this project, we did not feel that sufficient time existed to select an expert prior to the submission of this plan of study. Therefore, we propose to utilize the first year of the study (1980) to determine which individual is best qualified to assist on this aspect of the study effort. The two criteria that will be applied in the selection process are: (1) expert qualifications in dealing with the species involved, and also familiarity with these species in similar taiga/tundra ecosystems, and (2) total independence from any interest or concerns with the study area or the political aspects of Alaskan wildlife resource management.

The impact assessment will deal with both short-term impacts, such as construction activity, as well as long-term impacts which could involve disruption of movement patterns or predator-prey dynamics. The impact zone on these species will be very large and probably include the entire upper Susitna River basin as well as downstream portions, particularly to Talkeetna where major changes in flooding patterns, and thus riparian habitat will take place.

Of paramount importance in the impact assessment throughout the impact zone will be the location and distribution of critical habitat, particularly in regards to potential barriers created by the impoundments. This will be of prime importance to moose and caribou, species whose annual habitat needs vary from season to season and also differ under various weather conditions. An associated concern, particularly in regards to wolves, and to a lesser extent bears, will be the location of denning sites. Whether or not traditionally used wolf dens are flooded, or disturbed by human activity, will likely influence the occurrence, at least in the near future, of wolves in the Susitna basin.

Although the specifics of the impact assessment effort will be of a dynamic nature, and thus subject to change as the baseline data are collected and engineering information received, the general philosophy underlining the assessment will be to consider the entire terrestrial system and not only one isolated species at a time. Impacts on one big game species will certainly result in associated impacts on other components of the community, both faunal and floral. Likewise, impacts on some non-game components of the system will possibly have an indirect impact on a particular big game species. It is for this reason that the wildlife study proposed by TES

thoroughly covers all components of the terrestrial system. To do otherwise would result in data voids which could reduce the accuracy of impact predictions on big game, or other faunal groups.

MITIGATION

Operating under the assumption that the net effect of the Susitna Project on big game will be of a negative nature, it will be necessary to consider mitigation measures that can be taken. Mitigation measures can be grouped into two categories. First are efforts that can be implemented to reduce the impact of the project on the game populations within the study area or impact zone. Such steps as a schedule of water releases designed to minimize the obstruction of movement patterns, or the use of prescribed burning downstream to replace the effects of flooding in the maintenance of early successional plant growth in the riparian zone can be arranged as mitigative efforts. The second type of mitigation measures involve the improvement of habitat outside of the impact zone to increase game populations to an extent which would compensate for losses attributable to the dams.

In either case it will require the collection of at least two years' data before enough is known about likely impacts so that a mitigation plan can be formulated. The plan of study proposed by TES includes time and expenses to consider and identify possible mitigative alternatives. However, at this point in time, based on the available information, it would have been premature and highly speculative to propose a full-scale effort to develop a mitigation plan. It is, therefore, recommended that during 1982 either ADF&G or TES submit to the APA a proposal and associated cost estimate to develop a mitigation plan. At that point sufficient information, both of a biological and engineering nature, will exist upon which to structure a well designed program to address the issue of mitigation efforts for big game.

FURBEARERS

INTRODUCTION

The tasks described herein are designed to assess the probable effects of the Susitna Hydroelectric Project upon furbearers. Furbearers to be investigated include red foxes, coyotes, lynx, pine martens, beavers, muskrats, and river otters. A team of researchers will work with Dr. Gipson to develop a concise and factual assessment of furbearer resources in the region and to project impacts of the project upon these resources.

We must recognize that various furbearers will probably be affected differently by the proposed project. Some may decline in abundance while others may respond in a positive manner to the man-modified environment. The critical elements to assess are the net effects of the project upon each furbearer species, and then the net effects of the project upon the interacting system of plants and animals of which the furbearers are part.

APPROACH

The studies described below were designed to assess probable impacts of the Susitna Hydroelectric Project upon furbearers of the Susitna drainage. Studies of furbearers will be synchronized with field and laboratory investigations conducted by project personnel preparing vegetation cover type maps and conducting studies of project impacts upon other terrestrial mammals and birds.

A two phase approach will be followed and will include three steps: (1) a thorough review of the literature relating to physiography of the region, the wildlife and plant resources, and the needs of Alaskan people that utilize the wildlife resources, including sport trappers, subsistence trappers, hunters, and non-consumptive wildlife enthusiasts, (2) field investigations to provide essential data about furbearers and their habitats that is not presently available for the region, and (3) analysis and synthesis of data and development of predictions of impacts of the project.

SCOPE OF WORK - PHASE I

Phase I (1980 and 1981) will focus on essential data for a generalized assessment of the project upon furbearer populations. The primary effort during Phase I will be directed at determining seasonal abundances and critical foraging areas of the respective furbearers in the vicinity of the two impoundments and long downstream portions of the Susitna River that will be influenced by modified stream temperatures and flows.

Phase I field work for each furbearer species will include seasonal population surveys, and mapping of favored foraging areas. A combination of aerial surveys and intense work on the ground and on the river will be employed.

SCOPE OF WORK - PHASE II

During Phase II (1982, 1983, and 1984) emphasis will be placed on gathering long term data and assessing long term impacts. In order to achieve these goals it will be necessary to determine the home ranges and seasonal movement patterns of each furbearer species. Radio telemetry will be used during Phase II to aid in locating and monitoring furbearers. In addition, information concerning food habits and predator-prey dynamics will be considered during Phase II. Phase II activities will include continued monitoring of study animals to determine annual movements, long term population changes and adaptations by furbearers to altered environments.

Furbearer harvest records, pelt prices and subsistence uses of furbearer pelts from the impact zone will be reviewed and a survey of trappers in interior Alaska will be made to evaluate the economic importance of furbearers to primary user groups. Local residents of areas adjacent to the impact zone will be interviewed to determine the importance of furbearers to their style of life. Members of conservation organizations concerned primarily with observation and photography of wildlife will be surveyed to assess the importance of furbearers to non-consumptive wildlife enthusiasts.

Based on collected data, appropriate mitigation alternatives will be considered during Phase II. There are presently a few possible mitigative actions that could be taken in regards to some furbearer species; hopefully, others will be developed during the course of the furbearer study. For example, controlled burning in downstream areas may be effective in maintaining desirable early successional stages of plant growth. Another possibility may be to release a substantial flow of water in early spring to coincide with melting of river ice so that high water and floating ice will scour the river banks and gravel bars to remove old growth vegetation and encourage early successional vegetation. A third possibility may be to utilize vegetation crushing machines, such as those employed on the Kenai National Moose Range, to remove old growth vegetation. A fourth consideration will be to assess possible desirable effects of permitting the downstream riparian vegetation to mature.

BIRDS AND NON-GAME MAMMALS

INTRODUCTION

Almost nothing is known of the birds and small or non-game mammals of the upper Susitna River basin. The U.S. Army Corps of Engineers (1977) states that "unknown numbers of game birds ... (and) .... other small birds are found throughout the Upper Susitna River Basin in varying number"; they fail to mention small or non-game mammals. It appears, however, that the region is somewhat typical of other regions of central Alaska taiga and alpine tundra. On the basis of this similarity, there are probably 160 or more species of birds that use the upper Susitna River basin with some regularity, either as residents and/or breeders or as migrants and visitants, and perhaps 18 species of small- to medium-sized non-game mammals.

The only specific bird studies that have been done in the region are two cliff-nesting raptor surveys sponsored by the U.S. Fish and Wildlife Service, "Survey of the Peregrine Falcon and other raptors in the proposed Susitna River reservoir impoundment area" in 1974, and "Raptor studies along the proposed Susitna powerline corridors..." in 1975. These brief surveys found no evidence of the endangered Peregrine Falcon nesting in the immediate vicinity of either proposed dam site, but their status should be rechecked before human activity in the area increases significantly.

Additionally, personnel of the Alaska Department of Fish and Game report that the Susitna River basin between the Copper River-Susitna uplands and Gold Creek may be a major east-west migration corridor, at least for waterfowl.

The small mammals of the region have never been surveyed and are essentially unknown, except by inference.

The overall objective of the studies proposed below is to determine what species of birds and small- to medium-sized mammals use the upper Susitna River basin in the vicintiy of the proposed impoundments and to determine on a seasonal basis the habitats in which they are found and their abundance. These data can then be used to evaluate habitat potential in the area, to extrapolate population data for given geographic or habitat units within the region, and to evaluate possible mitigative measures, should they prove necessary.

APPROACH

We propose to use an extensive approach as well as an intensive approach for these studies. The extensive bird study (Phase I) will alert us to the presence of possibly unexpected species or unexpected concentrations of species, and it will enable us to compare the avifauna (species, relative abundance, habitat use, and seasonal chronologies) with better-known Alaska taigas, giving us a better base for predictions. The extensive study will also provide natural history and other data on species not found in the habitats of the intensive study sites. The extensive avian study will be conducted during Phase I (1980 and 1981) and will provide a sound data base upon which to organize a meaningful intensive survey during Phase II (1982 and 1983).

The intensive study sites in the upland and wetland habitats (Phase II) will provide data on bird species composition and density in each of the most extensive habitats of the region, providing, among other things, an indication of habitat uniqueness and productivity. These intensive sites should provide data that can be extrapolated to similar habitats throughout the upper basin and should provide a basis for predicting faunal changes based on habitat changes caused by environmental alternatives, including changes in water level. The small mammal effort will start in Phase I and continue through Phase II in order to cover the 4-year period needed to adequately document the cyclic population changes demonstrated by members of this group. In general, the small mammal data will enable an analysis similar to that performed for birds.

SCOPE OF WORK - PHASE I

AVIFAUNAL SURVEY OF THE UPPER SUSITNA RIVER BASIN (INCLUDING RAPTORS AND WATERFOWL)

A survey of the avifauna of the upper Susitna River basin will be conducted within an approximate 10-mile band on either side of the river, from Gold Creek to the upriver location above which the impoundment will not influence the current habitat (approximately 2000 square miles). Particular attention will be paid to long-lived species, those that are particularly sensitive to human disturbance, those subject to hunting pressure, and any endangered species (raptors, cranes, swans, grouse and ptarmigan, etc.).

Objectives

a. Determine all species of birds using the region.

b. Determine, on a seasonal basis (winter, summer, spring and fall migration), each species' relative abundance and general habitat use.

c. Determine spring and fall migration dates (earliest, latest, peak) and, insofar as time permits, the seasonal chronologies of each species.

d. Determine extent and type of use of the area by the peregrine, bald eagle, and osprey (endangered or threatened species).

Methods

a. More or less continous field observations will be conducted from about 10 April until mid-October, and at least one mid-winter period of observation will be undertaken.

b. All habitats of the region will be visited on a regular basis throughout the migration and summer periods, and all birds seen or heard will be recorded. This activity will provide data on seasonal use of the entire region by birds and provide a basis for determining the relative abundance of various species by season.

c. Time spent (or distance traveled) by the observer in various habitats will be recorded, to provide a basis for determining relative abundance of species within habitats as well as a general indication of habitat productivity. (These data will supplement those from the intensive survey to be conducted during Phase II and will include habitats not sampled during Phase II.)

d. Dates indicative of seasonal chronologies will be recorded (migration, nesting, fledging, molting, etc.).

e. One (perhaps two) aerial surveys will be made each year to search for evidence of large nesting raptors--osprey, bald and golden eagles, peregrine, and gyrfalcon.

f. Aerial surveys of waterfowl will be conducted over wetland areas periodically throughout the migration and summer seasons.

Significance of Results

The results of this study will provide:

a. A comprehensive overview of the avifauna of the region, including seasonal chronologies and relative abundance. This overview of a relatively unknown region will allow comparisons with better-known Alaska taigas; and, based on similarities or consistent differences, should enable conclusions and predictions for the Susitna area after only a few seasons' field work.

b. Evidence, during the first season, of possibly unexpected species or unexpected concentrations of species. (Is there a migratory movement of Sandhill Cranes through here? How large is the waterfowl movement? Etc.)

c. Data on the extent of raptor populations in the region. Since the 1974 USFWS survey found nothing untoward in respect to raptors of the region, a separate task to substantiate this information appears unnecessary.

d. Data on the occurrence and general utilization by waterfowl of wetlands during migration and breeding. This information will be used to develop a more detailed study plan for obtaining information on the type and degree of use of the different wetland types of the region during Phase II, if more intensive work appears necessary.

SMALL MAMMAL POPULATIONS AND HABITAT UTILIZATION

Objectives

a. Determine all species of small and medium-sized non-game mammals occurring in the region.

b. Determine for each of the major habitats of the region, species composition, relative abundance, and habitat use.

Methods

a. Trapline transects will be established in each of the major terrestrial habitats in the vicinity of the proposed dam sites and in several wetland habitats.

b. Censusing of the smallest mammals (shrews, voles, and mice) will be conducted using the North American Census of Small Mammals snap-trapping technique (Calhoun, 1948). Two parallel transects will be established, each a straight line, 289 m long, consisting of 20 trap stations. At each station, a maximum of three snap-traps and one pitfall trap will be set for three consecutive nights.

c. One late-spring/early-summer, one fall, and possibly one winter census will be conducted on each of the habitat plots. Sampling will be conducted during 1980 and 1981 of Phase I and continued through Phase II (1982 and 1983).

d. Habitat data at each trap site will be gathered in coordination with that gathered for the avian studies, using the point-centered quarter method of Cottam and Curtis (1956), with additional variables used to quantify ground cover and other microhabitat variables. If a winter census is made, snow cover characteristics will be sampled (e.g., snow depth, density and hardness, layering, etc.).

e. For each of the habitats censused, mammal species composition and relative abundance will be calculated.

f. For each small mammal species of sufficient sample size, quantification of macro- and micro-habitat preferences will be attempted.

g. More general methods will be used to quantify the presence of such species as the little brown bat, collared pika, snowshoe hare, hoary marmot, arctic ground squirrel, red squirrel, or flying squirrel. Within the study plots, the relative amount of sightings and sign (burrow entrances, cone "middens," scat, etc.) will be tabulated, and attempts will be made to locate and map any concentrations of hoary marmot and arctic ground squirrel.

h. Some random trapping will be conducted, as time and opportunity permit, in other parts of the upper Susitna River basin area and in lesser habitats not covered by the main plots, in order to permit the detection of species in the area that may not occur on the intensive plots.

Significance of Results

The results of this study will provide, for small and non-game mammals, data on species composition, relative abundance, and habitat preferences that can be used in determining the effects of habitat loss and alterations resulting from the proposed dam construction and subsequent impoundment of water in the upper Susitna River basin.

SCOPE OF WORK - PHASE II

AVIAN UTILIZATION OF TERRESTRIAL HABITATS

Objective

a. Determine, for each of the major upland habitats, the type and degree of use by birds, including species composition and density during summer and winter.

Methods

a. Census plots will be established in each of the major terrestrial habitats in the vicinity of the proposed dam sites. Wherever possible, these plots will be square 10-ha plots on sites of uniform habitat.

b. Habitats will be selected on the basis of Kessel's (in press), "Avian habitat classification for Alaska," a system which appears largely compatible with Walker et al. (MS), "A large scale (1:6000) vegetation mapping method for northern Alaska." A priori, it appears that avian utilization of 8-10 habitats should be examined.

c. Censusing will be done with a modification of the territory mapping method (Williams 1936, Kendeigh 1944, International Bird Census Committee 1970). During the breeding season, 7-9 censuses will be conducted on each plot; 1 or 2 censuses will be conducted during the winter months.

d. The habitat for each bird census plot will be sampled in detail, using the point-centered quarter method of Cottam and Curtis (1956), with modifications to include sampling of ground cover and shrub vegetation.

e. For each of the major habitats censused, avian species composition and density will be calculated.

f. For each of the more common bird species in the upland habitats, determination of habitat preferences will be attempted through the use of multivariate statistical techniques (1983 only).

Significance of Results

The results of this study will provide quantitative data significant to the evaluation of the environmental impact of the Susitna Hydroelectric Project.

a. We will know which of the terrestrial habitats in the upper Susitna River basin support the greatest density and the greatest diversity of birds, and which the least.

b. We will know what different kinds of birds use the major habitats of the upper Susitna River basin; and we will know something of the individaul habitat preferences of these

species and the abundance (density) of each species in these major habitats.

c. These data on habitat productivity and avian habitat preferences will provide insights into the effects of construction activities and subsequent impoundments on the avifauna of the region. It will show which species will be most affected, for example, when construction involves white spruce forests or shrub thickets as opposed to deciduous forests, and vice versa. Conversely, it will be possible to predict what species will be attracted to the region after construction, based on habitat changes caused by construction (revegetation) or changes in water level (changes in substrate moisture alter vegetative habitats).

d. Should it prove desirable, based on a vegetation map, it should be possible, through extrapolation, to roughly estimate the number of birds of each species that will be displaced from terrestrial habitats as a result of habitat destruction caused by construction and impoundments.

WATERBIRD UTILIZATION OF WETLANDS[1]

Objective

a. Determine, for each of the major wetland habitat types of the region, the type and degree of utilization by waterbirds, especially loons, grebes, and waterfowl.

Methods

a. Wetlands will be classified as to habitats and habitat types, based on such characteristics as size and depth of pond, type of shoreline, presence of submergent and emergent vegetation, wet meadows, depth and size of streams and speed of current, etc.

b. Species composition and density of waterbirds using the various habitat types will be determined on a seasonal basis--migration, nesting, brood-rearing, and molting.

c. Aerial and ground census methods will be selected on the basis of the background information obtained during Phase I.

Significance of Results

Wetland habitats, in general, are among the most productive of all habitats; and waterfowl include many important game species for North American hunters. Hence, if the upper Susitna River basin is, indeed, a major waterfowl migration flyway, or if significant wetland areas are to be flooded (or to be formed by flooding), information on the type of use and amount of use by various waterbirds must

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1. To be initiated in 1982 only if results of Phase I observations indicate need.

be known. Such knowledge will be required to evaluate the overall environmental impact of the hydroelectric project if significant quantities of waterbirds and wetlands occur in the region.

SMALL MAMMAL POPULATIONS AND HABITAT UTILIZATION

Objective

The objective of the Phase II portion of the small mammal effort is to gather data over an additional two-year period in order to adequately describe this very important component of the terrestrial system.

Methods

Phase II methodology will be basically the same as Phase I. It is likely, however, that some refinement in sampling methodology will occur based on knowledge accumulated during Phase I. This will serve to meet the dynamic needs of this project, and also insure that optimal results are obtained.

Significance of Results

As stated previously, many small mammal species in taiga and tundra communities display cyclic properties. Therefore, a minimum of four years is needed to document the extent of density changes. This information is extremely important because the population levels of small to medium-sized mammals have far-reaching impacts on the other members of the faunal community. In order to adequately predict the impacts to be expected from the Susitna Project it will be necessary to document this key component of the terrestrial system and establish the role played by this group in the ecology of the upper Susitna River basin.

LITERATURE CITED

Calhoun, J.B. 1948. North American census of small mammals. Release No. 1, Rodent Ecology Project, Johns Hopkins University. Baltimore, Maryland.

Cottam, G., and J. T. Curtis. 1956. The use of distance measures in phytosociological sampling. Ecology 36:451-460.

International Bird Census Committee. 1970. Recommendations for an international standard for a mapping method in bird census work. Audubon Field Notes 24:727-736.

Kendeigh, C. S. 1944. Measurement of bird populations. Ecol. Monogr. 14:67-106.

U.S. Army Corps of Engineers. 1977. Final environmental impact statement, Upper Susitna River basin, southcentral railbelt area, Alaska. Washington, D.C.

U.S. Fish and Wildlife Service. 1974. Survey of the Peregrine Falcon and other raptors in the proposed Susitna River reservoir impoundment areas.

U.S. Fish and Wildlife Service (and other agencies). 1975. Raptor studies along the proposed Susitna powerline corridors, oil pipeline, and in the Yukon and Colville River regions of Alaska.

Williams, A. B. 1936. The composition and dynamics of a beech-maple climax community. Ecol. Monogr. 6:317-408.

SUBTASK 7.12

PLANT ECOLOGY ANALYSIS

OBJECTIVES

The objectives of the plant ecology program are to map and characterize the vegetation and habitat types occurring in the areas to be affected by the proposed Susitna Hydroelectric Project in a qualitative and quantitative sense and to predict impacts that will result from the proposed facilities.

APPROACH

Vegetation types will be mapped on topographic maps of the area as well as on LANDSAT, high-altitude (U2), and low level aerial photography. Respective land areas covered by each vegetation/habitat type will be determined by manual planimetry or computer integration from LANDSAT imagery after the types have been circumscribed. Ground verification will be determined by the accessibility of outlying portions of the Susitna River area and the time constraints imposed by a relatively short field season. Quantitative sampling will be performed in the major vegetation types.

Sensitive habitats, especially wetlands and those containing endangered or threatened species of plants, will be emphasized, and any natural landmarks (U.S. National Park Service Programs) in the area will also be noted.

Impact assessment of the overall ecological effects of the dam project and the siting of transmission lines will be made as the proposed routes are announced, and the field studies are completed. Data presented in the reports will be supported by available regional literature.

DISCUSSION

The characterization of vegetation types within an area provides a great deal of information for use in environmental studies. Such information is not only used for the prediction of impacts on plant communities, but it is also used in predicting wildlife habitat removal and changes in land use patterns. Past FERC license applications have usually included vegetation cover type maps, a detailed description of vegetation types, a discussion of threatened or endangered species, and a description of vegetation impacts. The proposed study includes these tasks.

DATA BASE REVIEW

Comprehensive searches of the scientific literature will be made to generate a bibliographic and actual data base on the Susitna Region, and on similar types of vegetation in Alaska and adjacent Canada. These studies will consist of literature searches in standard bibliographic sources (Biological Abstracts, Wildlife

Review, etc.), data collation from literature on methods and other studies of Alaskan vegetation, government institution reports, and vegetation impact studies in other northern regions. Methods used in other quantitative ecological studies of boreal forest or taiga in other northern regions will be included in the searches. Literature dealing with the effect of water level changes on riparian vegetation, such as Teskey and Hinckley (1977), will also be reviewed. A list of the plant species encountered will be produced, with identifications checked in floristic works available at this time, such as Hulten (1968), and known collections of Alaskan plants in herbaria.

PLANT COMMUNITY ANALYSIS

VEGETATION COVER MAP

The use of LANDSAT imagery and high altitude (U2) photography will be used to map vegetation types in the Susitna River Basin. The vegetation is primarily boreal forest types and upland tundra. This type of photography has proven adequate to delineate the types occurring in the area according to recent experience of staff of the Alaska Agricultural Experiment Station (AAES). Low-level aerial photography (aerial quadrants) has been used to obtain quantitative information in boreal forest types in central Canada and is currently being used in the Susitna River Basin by the U.S. Soil Conservation Service and U.S. Forest Service. With a calibrated camera system, the number of stems, height, and general cover values can be obtained. The aerometric studies (aerial photography) involve detailed study of LANDSAT imagery in black and white, color (false IR and conventional), and multi-spectral photography as it becomes available for Alaska from recent satellite launches.

The vegetation/cover map will be prepared for the proposed impoundment areas, transmission corridor, access road corridor, and some of the downstream flood plain of the Susitna River. The extent and intensity of the mapping in the downstream flood plain will depend upon water level fluctuations. For the purposes of the vegetation mapping, coverage will concentrate on the flood plain downstream to Talkeetna, since it is anticipated that this will be the area of greatest vegetation and habitat impact due to the changes in flow caused by the impoundments.

Preparation of the cover map will begin in early 1980 with the acquisition of LANDSAT and presently available color/IR aerial photography of the Susitna River Basin. Study of the LANDSAT imagery will yield an initial delineation of vegetation types in the Susitna River Valley which will be preliminary and require extensive field verification. The initial mapping effort will attempt to delineate the occurrence of wetland areas. This will be done to aid in the compliance with Section 404 of the Clean Water Act prior to surface disturbing activity.

Field verification of vegetation types will be performed primarily during the 1980 field season, but it will continue during the following field seasons as selected areas and stands of vege-

tation are studied and sampled by various quantitative ecological methods. Respective land areas covered by each vegetation type will be determined by manual planimetry or computer integration from the LANDSAT imagery. A table showing the acreage of each vegetation type and percent of total study area acreage will be presented in the report.

VEGETATION SAMPLING

Quantitative vegetation data will be obtained from proven techniques employed by plant ecologists and forest scientists in determining the distribution of plant species in vegetation types and in describing community structure. Relationships of plant communities to topographic, geological, and edaphic factors will also be noted.

Herbaceous and low shrub layer vegetation will be sampled by clipping 0.25 m^2 quadrats in the various habitat types. In a current study at the AAES this method has been used successfully to measure biomass in a range of vegetation types in the Matanuska Valley. The communities in the Matanuska Valley study included representative types similar to those in the proposed study areas. Variance estimates from the Matanuska Valley study will be used to calculate the number of samples required in the Susitna Project.

Browse biomass will be calculated from canopy cover measurements on aerial photographic imagery. Regression equations will be developed to relate canopy cover for the several, but well defined shrub types in the Susitna Valley. This will necessitate harvesting methods on several selective representative sites. Timber resources will be calculated from aerial photographic type maps verified by field checks using standard mensuration practices of the U.S. Forest Service and the State of Alaska, Division of Forestry.

Whenever possible, data will be recorded directly on computer-compatible forms in the field as the quantitative sampling is done. With the large mass of data anticipated, the only feasible means of maintaining organized and accessible files are in a computer data base. Recent experience at the University of Alaska during International Biological Program (IBP) tundra biome studies will be useful in this area.

Field data from quantitative sampling methods will be transferred from field forms to punched cards and entered in the computer data base. Recall and printout of the data on any site and for any season in the Susitna River area will be possible. Surveyor's land designations shall be used so that any study site may be found on readily available maps. If advanced statistical studies are required or desirable, ordination and canonical analysis can be made of the vegetation stand data by an available scientist who has made similar analysis of forest vegetation types.

Photographic map verification will begin in the June-September, 1980 period. Quantitative sampling will begin in 1983. The use of the Devil Canyon lodge or field camps in the Susitna River area as forward field camps for the plant ecology teams is anticipated, with the AAES at Palmer being used as the staging area. Remote field camps will be made in approved areas utilizing helicopter drops to minimize vehicular impact. Equipment necessary for remote field camps will be obtained for the program.

The field season (June-September) will be divided into 3-5 periods of 3-4 weeks during which one or two senior scientists will be present in the Susitna River area and be assisted by three or four junior personnel.

Aquatic plant communities will be studied by an appropriate botanical expert beginning in the 1983 field season. Aquatic plants will be described wherever they occur, and notes on frequency, abundance, and vigor will be made in the field survey. The aquatic flora is not large and most of the species are known to the botanical team.

ENDANGERED OR THREATENED SPECIES

Presently there are no plant species listed for Alaska as endangered or threatened by federal or state authorities. However, six species have been proposed by the Fish and Wildlife Service (USDI 1976) for protection as endangered species under the Endangered Species Act of 1973. For these six species distribution and habitat information will be assembled from literature and herbaria sources. Known stations and potential habitats for these species in the study area will be searched to determine the present status.

IMPACT ANALYSIS

All potential impacts of the proposed projects on vegetation will be discussed in the reports. The accuracy of impact predictions will vary depending upon the area under consideration. For the impoundment areas and transmission line rights-of-way, very accurate values of the total acreage of each vegetation type to be destroyed by the proposed facilities can be determined. The effect of the proposed facilities on downstream flood plain vegetation will be more difficult to accurately predict. Vegetational changes will occur in this area as a result of: possible changes in spring flooding, year-round ground water level changes, and, potentially, ice damage. The physical changes will result in a number of interacting vegetation changes.

Spring flooding and high water tables during certain times of the year are probably instrumental in the perpetuation of certain riparian plant communities. The dams will regulate flow which should result in decreased spring flooding. This may be offset to a certain extent by melting ice, if a substantial ice buildup occurs below the dam. Decreased flooding may permit riparian

habitats to develop along successional pathways into more mature communities. This is, of course, a long-term process, but it may eventually result in a reduction in the amount of the existing plant communities. The long-term loss of this type of habitat may, however, be temporarily offset to a certain extent by shrubs invading onto gravel bars and other areas that were previously devoid of vegetation as a result of flooding and scouring activity.

As previously mentioned, the downstream flood plain will provide a number of interesting problems. Plant ecological information will be used in conjunction with various physical data to aid in predicting changes. Depending upon the accuracy with which the botany personnel feel that they can predict vegetation changes, a map indicating type and extent of changes may be produced. Supplementary field information required for predicting impacts will be acquired during the 1981 field season, with more detailed quantitative data and impact information being collected in 1982 and 1983.

LITERATURE CITED

Hulten, E. 1968. Flora of Alaska and neighboring territories. Stanford University Press, Stanford, CA.

Teskey, R.O., and T.M. Hinkley. 1977. Impact of water level changes on woody riparian and wetland communities. USDI Fish and Wildlife Service, Office of Biological Services, FWS/OBS-77/58.

USDI. 1976. Endangered and threatened wildlife and plants, proposed endangered status for some 1700 U.S. vascular plant taxa. United States Department of the Interior. Fish and Wildlife Service. Fed. Reg. 40:24524-24571.

SCHEDULE

Certain aspects of the program will be initiated at the start of the project and continue for its duration. In each year, planning and methods refinement will be performed in the first quarter, field sampling in the second and third quarters, and report preparation will be concentrated in the fourth quarter.