SUSITNA HYDROELECTRIC PROJECT

FEDERAL ENERGY REGULATORY COMMISSION
PROJECT No. 7114

AQUATIC PROGRAMS
FISCAL YEAR 1984
DETAILED PLAN OF STUDY

ARZA-EBASCO
USITNA JOINT VENTURE

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AQUATIC PROGRAM
DETAILED PLAN OF STUDY
FISCAL YEAR 1984

Report by

Harza-Ebasco Susitna Joint Venture

Prepared for

Alaska Power Authority

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1.0 INTRODUCTION

1.1 BACKGROUND

Task 4, the Environmental Program for the Susitna Project, is subdivided into three major areas of activity. These are: Social Science, dealing primarily with cultural, socioeconomic, recreation, aesthetic and land use resource issues; Terrestrial, dealing with wildlife, botanical and habitat resource issues; and, Aquatic, dealing with fisheries, aquatic habitat and water quality resource issues.

The general and specific objectives for each of these three programs have been presented in general investigation memoranda, along with the general methodologies by which these objectives will be accomplished.

This document presents a Detailed Aquatic Plan of Study for fiscal year 1984. Included are plans to accomplish all field or baseline data collection, analysis, assessment and mitigation planning activities scheduled for this period. Study sub-tasks are defined for each such activity and include as appropriate, the following elements:

1. a clear statement of the objectives of the sub-task and hypotheses to be tested;

2. a summary of previous studies;

3. a delineation of study area boundaries;

4. data specifications and formats;

5. detailed descriptions of methods, including sampling locations, frequencies, and techniques;

6. data management and analysis techniques;

7. specification of reports, report formats, and schedule for deliverables;

8. requirements and methods for coordination with other studies;

9. quality assurance plans and specifications; and

10. schedule of completion dates.

The Detailed Plan of Study serves as a tool for overall management and quality assurance in that it responds to agency issues and review comments and complies with state and federal statutes and regulations. As a "blueprint", the Study Plan is compared with the study results to determine whether the stated objectives have been accomplished.

1.2 AQUATIC PROGRAM

The Aquatic Program Detailed Plan of Study presented below consists of numerous elements to be conducted by various participants. These participants have primary responsibilities as follows:

1. The Alaska Department of Fish and Game (ADF&G) Susitna Hydroelectric Aquatic Study Team is responsible for all baseline biological and habitat data collection and analysis. This work is intended to provide a description of the abundance and seasonal distribution of fish in the study area, the specific habitats available to the fish in the river, and correlate the relationship between mainstem discharge, temperature, turbidity and other water quality parameters to the aquatic habitat utilized by the fish.

2. R&M Consultants have the primary responsibility of providing baseline data on hydrologic, hydraulic, water temperature and

climatic conditions in the Susitna River for use in the baseline evaluation and for modeling of natural and with-project basinwide conditions.

3. E. Woody Trihey and Associates (EWT&A) serves a liaison and coordination function among the other participants and is responsible for providing expertise to the ADF&G in the hydraulic analysis of the habitat types located in the Susitna River. EWT&A will also be responsible for the instream flow vs habitat report.

4. The Artic Environmental Information and Data Center (AEIDC) is responsible for the analysis of the effects of alternative operational regimes on fish and their habitats.

5. Woodward Clyde Consultants has primary responsibility in developing the plan for mitigating the adverse impacts of the proposed project on the aquatic habitats. They will assist in preparation of the instream flow report and developing a habitat modification workscope.

6. The Harza-Ebasco Susitna Joint Venture Aquatic Program Staff has the overall responsibility of management of the study program, coordination of the study participants and for the technical quality of the results of the program.

In addition to the Harza-Ebasco Aquatic Program Staff, the Hydrologic and the Hydraulic Studies Staff of Harza-Ebasco has the responsibility for providing results of mathematical models which will predict with-project conditions in the following areas:

1. Reservior operation;
2. Reservoir temperature and ice conditions and temperature of water discharge from the project;

3. Instream ice processes;
4. Suspended sediment and bedload transport processes; and,
5. Groundwater dynamics.

These studies are described in the Investigation Memorandum of the Hydrologic and Hydraulic Studies.

2.0 STUDY OBJECTIVES

2.1 OVERALL OBJECTIVES

The objective of the Aquatic Study Program is to provide a quantitative assessment of the effects of the Susitna Hydroelectric Project on aquatic resources in the Susitna River and develop a comprehensive plan to mitigate significant adverse effects. This quantitative assessment of effects is dependent upon: first; a quantification of how the aquatic resources respond to changes in physical conditions in the river under existing conditions; and, second; how the physical conditions in the river will be changed by project operation. These two aspects, then, provide primary objectives of the Aquatic Study Program.

The first of these primary objectives consists of several components which can be stated in the form of questions:

1. How do fish populations and their habitats respond to changes in the physical characteristics of the river?

2. How is navigation affected by discharge?

3. How is recreational use affected by discharge?

4. How is wastewater assimilation capacity affected by changes in chemical properties in the river?

5. How are riparian habitats affected by discharge in the river?

For the most part each of the latter four questions can be resolved through various analyses of data collected to answer the first question .
The second primary objective is to define how the physical and chemical characteristics of the aquatic habitat will change as a result of project operation. Basic changes to the physical characteristics of the aquatic

system downstream of the project dams include: discharge regime; temperature regime; turbidity, suspended sediment and bedload transport processes; and, other water quality parameters such as dissolved gas concentrations, nutrients, etc. The magnitude of these physical changes will be determined by the difference between natural conditions and a recommended operational discharge regime. Definition of these physical/chemical habitat changes will rely primarily on results of the modeling efforts performed by the Hydrology Study Team as presented in the Susitna Project Task 42 Work Plan for 1984 (Harza-Ebasco, 1983).

2.2 SPECIFIC OBJECTIVES OF THE FY84 AQUATIC PROGRAM

The specific objectives of the FY84 aquatic study program focus on the determination of how fish habitats, in the reach between Devil Canyon and Talkeetna, respond to changes in river discharge and temperature and, based on this determination, define discharge and temperature regimes required to maintain or possibly enhance the fish habitats.

The specific objectives of the FY84 Aquatic Study Program, stated in the form of questions, are as follows:

1. How is access to spawning habitats influenced by discharge in the river and what discharge is required to maintain access to the spawning habitat of adult salmon?

2. How are spawning habitats influenced by discharge and what discharge is required to maintain spawning habitats for salmon?

3. How is incubation of salmon eggs influenced by discharge and temperature and what are the required discharges and temperatures to assure successful incubation of the eggs?

4. How is juvenile rearing habitat influenced by discharge, temperature and turbidity and what discharge and water temperature is required to maintain rearing habitats?

5. How is outmigration of juvenile salmon affected by discharge and temperature and what discharge and temperature regimes are required to allow outmigration from the Devil Canyon to Talkeetna reach of the Susitna River.

Answering these questions with respect to the habitats utilized by each fish species will allow the determination of seasonal with-project discharge and temperature requirements to maintain the existing levels of fish production in the Susitna River.

3.0 GENERAL APPROACH

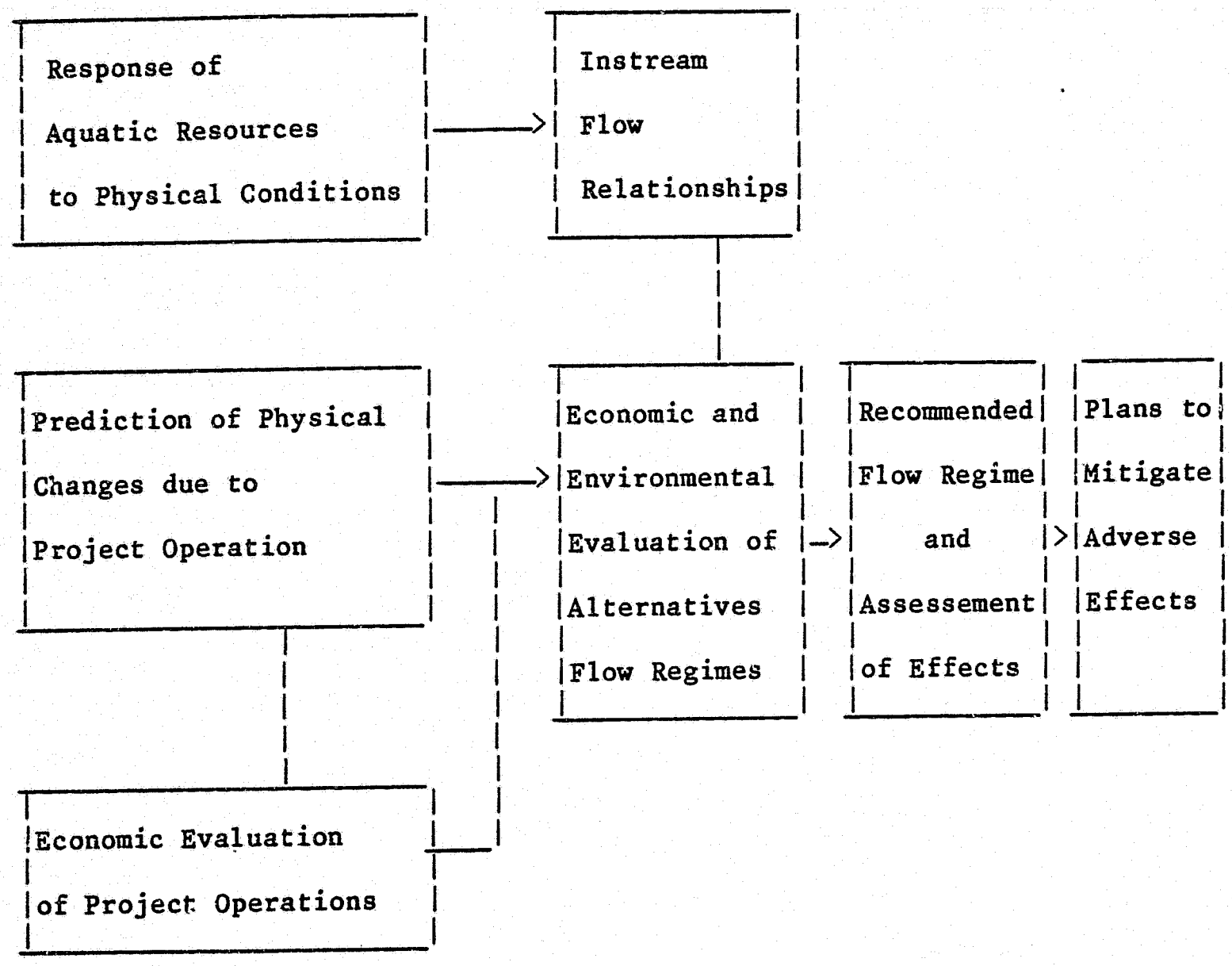
The general approach of the Aquatic Study Program is to provide an incremental iterative process through which the response of the aquatic habitat to changes in flow characteristics[1/] in the Susitna River can be quantified. Ultimately, this process will allow development of a recommended flow regime for operation of the Susitna Hydroelectric Project. The development of this recommended regime will be based on the results a quantitative tradeoff analysis between economic and environmental effects of alternative flow regimes. The approach consists of four basic steps:

1. Determine quantitatively how aquatic habitats respond to changes in flow characteristics;
2. Determine what flows will be sufficient to maintain existing aquatic habitats and resources;
3. Evaluate alternative flows, both environmentally and economically, perform a tradeoff analysis, and develop a recommended flow regime; and
4. Evaluate the effects of the recommended flow regime and prepare a plan to mitigate any unavoidable adverse effects of the recommended flow regime.
5. Identify options for providing enhancement of fishery resources and evaluate the costs and benefits

This basic approach is depicted schematically in Figure 3-1.

1/ For purposes of brevity, flow is defined here to include all characteristics of running water: Discharge, depth, velocity, temperature, turbidity, bedload, suspended sediment load and other water quality parameters.

FIGURE 3-1: GENERAL APPROACH
OF AQUATIC STUDY PROGRAMS



3.1 GENERAL METHODOLOGY

The incremental portion of this general approach consists of quantification of aquatic habitat availability for fish species through a specified range of flows in the river. A principal result of this portion is a

tabulation of flow increments and the associated indices of habitat values.

In order to accomplish this incremental analysis two basic questions must be answered:

1. What is the distribution and abundance of fish in the Susitna River and how do these change through time?

2. How do the habitats used by the fish respond to change in flow characteristics in the river?

ADF&G has determined that at least 19 species of fish inhabit the Susitna River. Previous and ongoing aquatic studies have focused on the abundance and distribution of the five Pacific Salmon species which occur in the system. The principal reason for this is the high recreational and commercial importance placed on the salmon by various organizations. It is assumed that analysis of the utilization of the river by these five salmon species and provisions to maintain these populations will also allow maintenance of the populations of other fish species, particularly sportfish such as rainbow trout and arctic grayling. Where necessary, as in the case of burbot, specific evaluation of other species' habitat requirements and potential with-project effects on these habitats will be conducted in parallel to the studies conducted on salmon.

In determining the utilization of the various habitats present in the river by the salmon species, it is necessary to consider specific stages in the life cycles of the salmon which occur in the fresh water system and which may have different specific habitat requirements. Important life stages of the salmon which must be considered include:

1. Migration and access to spawning habitat,
2. Spawning,
3. Incubation,

4. Rearing, and
5. Outmigration.

Within the Susitna River, ADF&G has identified six relatively distinct types of habitats which are used to a greater or lesser extent by various life stages of the salmon. These habitat types include:

1. Mainstem,
2. Side slough,
3. Side channel,
4. Upland slough,
5. Tributary Mouth, and
6. Tributary.

Each habitat type is used differentially by various life stages of the salmon and is also influenced differentially by mainstem flow. Table 3.1 presents a summary of the habitat types, the salmon life stages utilizing these habitat and the potential effects of altered flow regimes on these habitat types.

In applying the incremental methodology, our approach is to determine how each available habitat type is utilized by each salmon species and life stage of the salmon. Then we will determine how the habitat responds to changes in mainstem flow. Since each habitat type responds differently to changes in mainstem flow, a number of representative study sites for each of the above six habitat types are evaluated independently. This involves determination of how each individual study site responds hydraulically and biologically to changes in mainstem flow. Once these determinations are made, the responses will be aggregated by habitat type for each species to

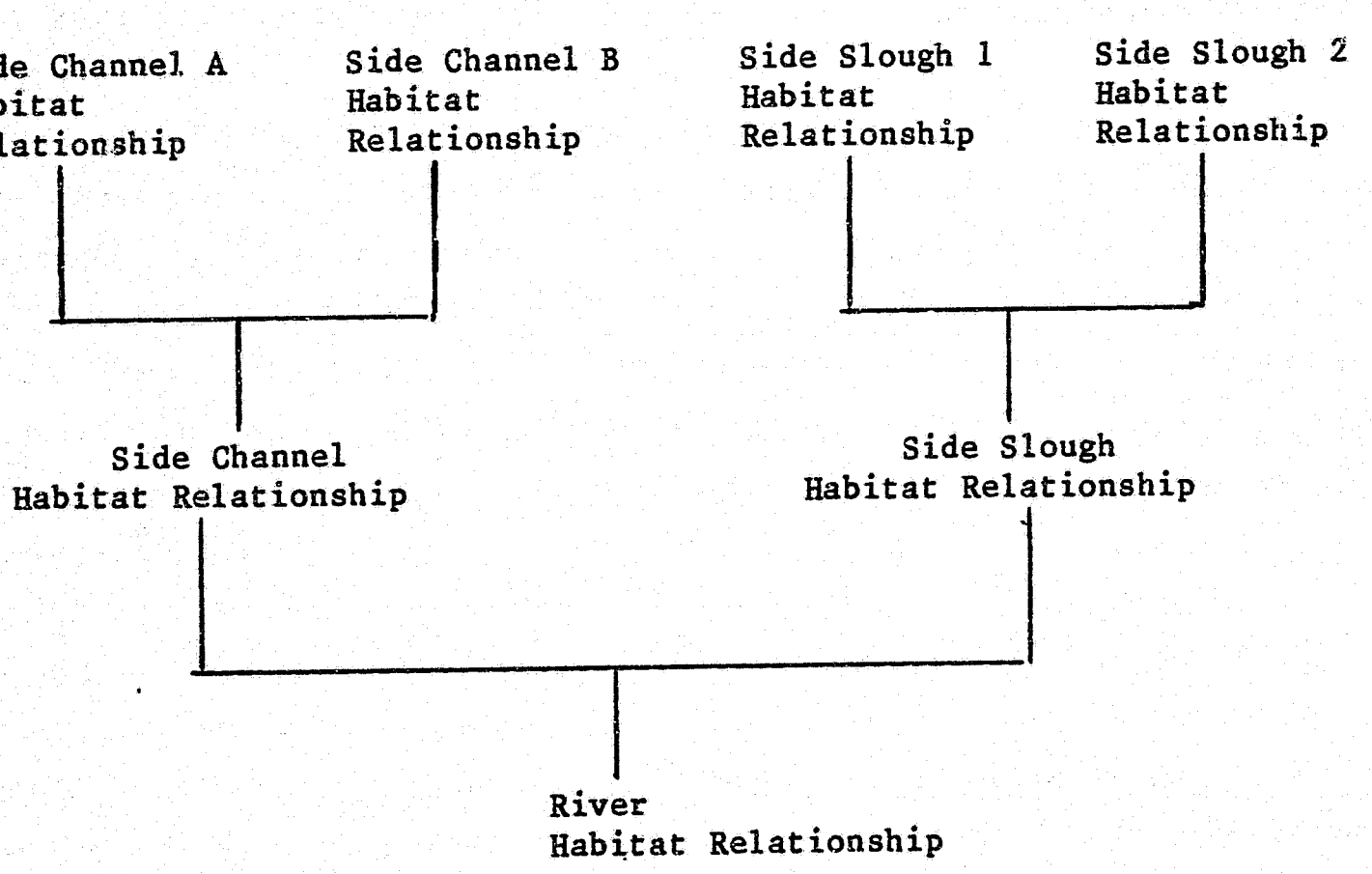
TABLE 3-1 (Rev. 3/84)

SUMMARY OF AQUATIC HABITATS
UTILIZED BY FISH

Habitat Type	Species Found	Utilization	Importance of Utilization	Potential Effects Due to Proposed Project
Side Sloughs	All Salmonid Species	Spawning Incubation Rearing	-Primarily spawning and incubation habitat for Chum, Sockeye and Pink Salmon -Rearing habitat for Chinook, Coho, Pink and Chum	-Reduced accesibility for spawning -Reduced spawning areas -Reduced rearing areas
Side Channels	All Fish Species	Rearing Spawning	-Not extensively used under existing conditions	-Potential transformation into side slough type habitats
Upland Sloughs	Chinook Coho	Rearing of juveniles	-Primarily utlized for rearing	-Loss of rearing habitat
Tributaries	Chinook, Pink, Coho, Chum, Rainbow, Arctic Grayling	Spawning Incubation Rearing	-Production of all Chinook and most Pink, Chum and Coho juveniles	-This habitat is not directly affected by proposed project -Major concern is potential inhibition of access to tributaries
Tributary Mouths	All Fish Species	Spawning Incubation Rearing	-Recognized as salmon spawning and resident rearing habitat; also provides access to tributaries.	-potential loss of rearing habitat of mouths tributary
Mainstem	All Fish Species	Migration Corridor, Rearing, Overwintering, Spawning	-Little use for spawning or incubation under existing conditions; primary importance for migration and some rearing	-Potential improvement of conditions for spawning and incubation

provide an index of how each habitat type (e.g., side sloughs or side channels) in the Devil Canyon to Talkeetna reach respond, to changes in mainstem flow. Once the indices by habitat type are obtained, they will be further aggregated to provide a single index of the response of fish habitat to mainstem flow in the Devil Canyon to Talkeetna reach. To accomplish this aggregation it will also be necessary to differentially weight the value of each of the species and their life stages to arrive at a single index of responses to mainstem flow. This process of aggregation is depicted schematically in highly simplified form in Figure 3-2 below.

FIGURE 3-2 SCHEMATIC PROCESS OF AGGREGATING SPECIFIC STUDY SITES TO AQUATIC SYSTEM IN SUSITNA RIVER



The iterative aspect of the approach begins with the incremental analyses and integrates the habitat relationships with the life stage utilization periods of the different fish species. This includes evaluating the effects on access, defined as those periods when the salmon are attempting to gain access to their spawning habitats. The analyses will differ for other time periods depending upon when other life stages of salmon are present in the system. This could also allow shifting of consideration of the importance of one habitat type in the analysis to consideration of another habitat type because of the differential usage by different life stages of the fish.

A principal result of the aggregation of the habitat responses through the life stage utilization periods is the development of a flow regime for the entire annual cycle on a monthly or weekly basis. This flow regime will be developed to define what flow regime is required to maintain or enhance existing fishery resources in the river.

Once this required flow regime is developed and the tabulations of habitat responses to mainstem flows are available, the iterative aspect of the approach allows for comparison of alternative flow regimes with the required flow regime. Alternative flow regimes used for comparison may include the natural flow regime as well as flow regimes proposed for operation of the project as presented in the License Application or as recommended by various resource agencies.

For each alternative flow regime for operation of the proposed project, a direct comparison with the required flow regime and the natural flow regime can be performed. By using the 32 year natural flow records and superimposing project regulation on the recorded flows (simulated operation), a analysis will be performed to determine the frequency with which given habitat index values will be met or excluded.

In parallel with the frequency analysis for habitat values, an analysis will be conducted of the economic costs and benefits of each alternative flow regime.

Comparison of the habitat values with the economic values will then lead to the trade-off analysis. Finally, results of the trade-off analysis will be used to develop a recommended flow regime for operation of the project which balances economic and environmental considerations.

Once a recommended flow regime is developed, a final assessment of the effects to the aquatic habitats will be developed and a plan for mitigating significant adverse affects will be prepared.

3.2 STUDY PROGRAM TASKS

Six study tasks have been developed and are identified by the life stage, the salmon species and the utilization of the habitat types. Several additional tasks are being developed and will be included in the study plan as they are completed.

The six tasks which are described in Section 4.0 are:

Task 1 - Evaluation of conditions providing access to spawning habitats

Task 2 - Evaluation of spawning habitats

Task 3 - Evaluation of incubation habitat

Task 4 - Evaluation of juvenile salmon rearing habitat

Task 5 - Evaluation of conditions related to outmigration of juvenile salmon

Task 6 - Preliminary evaluation of the reach between Talkeetna and Cook Inlet

Task 7 - Evaluation of the navigability of the river

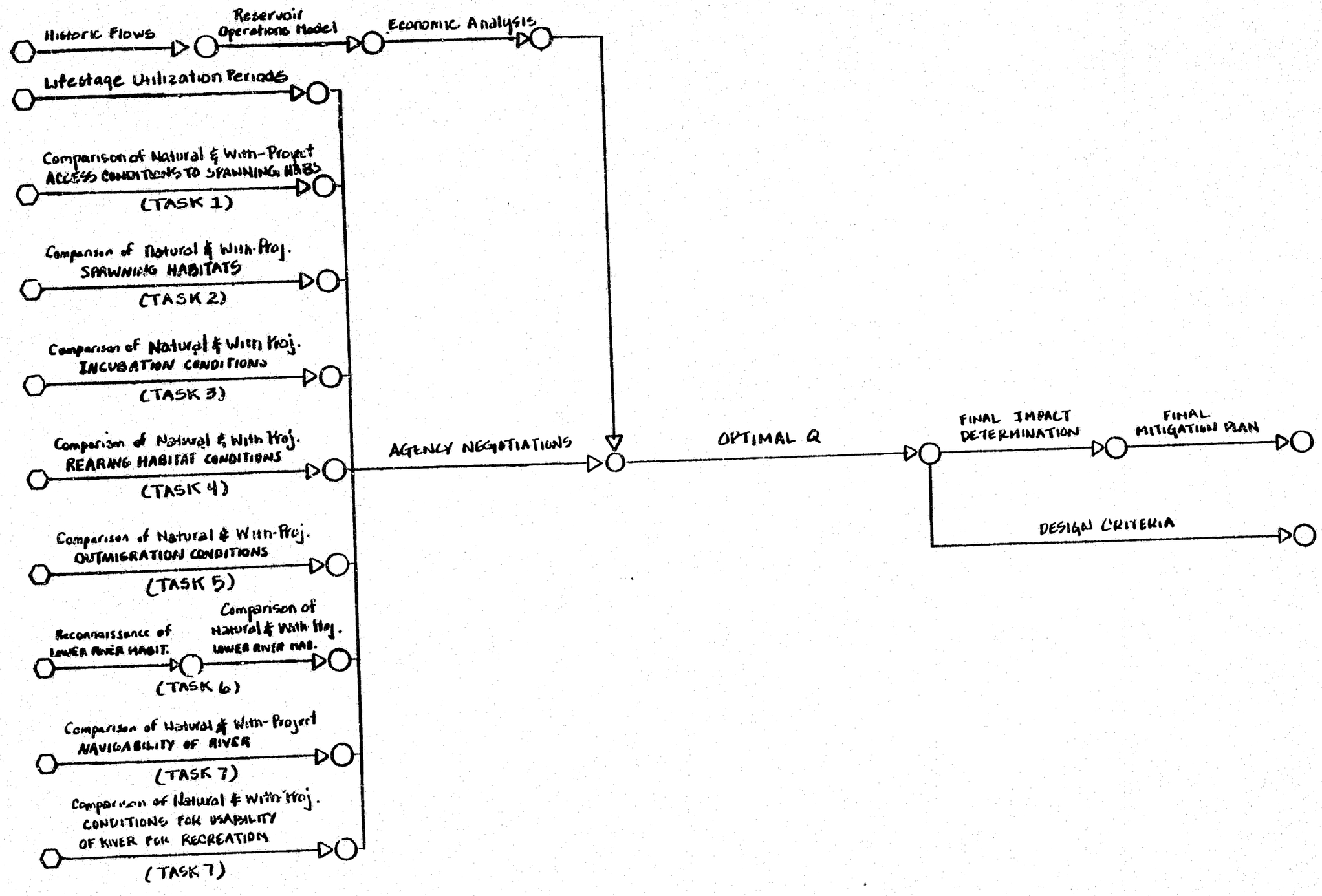
The first five tasks are identified for the evaluation of flow characteristics on specific life stages of the salmon. The analysis of these life stages is integrated through time to a single project flow regime for which the effects on the habitats can be quantified, as shown in Figure 3-3.

3.3 General Schedule for Aquatic Studies Program

A general schedule for activities conducted in the Aquatic Study Program is contained in Attachment 6.2.

FIGURE 3-3

OVERVIEW OF THE SUSITNA AQUATICS PROGRAM



4.0 STUDY TASK DESCRIPTIONS

The Aquatic Program encompasses all fisheries and aquatic habitat studies needed to support FERC licensing of the Susitna Hydroelectric Project. The specific study tasks have been developed based on review of previous study reports on the Project, review of the FERC License Application with emphasis on Exhibit E, and meetings with the Power Authority and aquatic studies sub-contractors. In addition, the Aquatic Program study tasks were designed to address issues and concerns expressed by the FERC, resource agencies and the public about fisheries/aquatic habitat impacts associated with the project; to quantify aquatic resources potentially affected by the Project; and to develop appropriate mitigation plans for adverse effects of the proposed project. The specific study tasks as previously mentioned in section 3.2 are:

1. Task 1 - Evaluation of Adult Salmon Access Conditions
2. Task 2 - Evaluation of Spawning Habitats
3. Task 3 - Evaluation of Conditions Influencing Incubation
4. Task 4 - Evaluation of Rearing Habitats
5. Task 5 - Evaluation of Conditions During Outmigration
6. Task 6 - Preliminary Evaluation of Hydrologic, Hydraulic and Thermal Conditions and Aquatic Habitats Between Talkeetna and Cook Inlet
7. Task 7 - Navigation/Recreation

4.1 TASK 1 - EVALUATION OF ADULT SALMON ACCESS CONDITIONS

4.1.1 Background

4.1.1.1 Rationale. A component of the freshwater life stages of the five salmon species which utilize various habitat types in the Susitna River between Devil Canyon and Talkeetna involves movement of the adults to the spawning areas.

For some of the spawning areas, the morphology of the streambed, coupled with the water surface elevation of the mainstem, can inhibit salmon movement into the spawning areas. Hence, an evaluation is necessary of the relation between the morphology of the streambed and the water surface elevation at various mainstem flows at the entrances to spawning area. Principal spawning habitats, for which evaluation of entrance or access conditions is required, include side sloughs, tributaries, and side channels.

The majority of salmon spawning in the Devil Canyon to Talkeetna reach occurs in the tributaries. Although no effect on the tributary spawning habitats per se is anticipated due to the proposed project, morphological conditions at the mouth of the tributaries could directly affect the numbers of salmon gaining access to the tributary habitats. Hence, a thorough evaluation of entrance conditions at tributary mouths is necessary.

The second largest proportion of salmon spawning occurs in the side sloughs which provide spawning habitat for some of the chum and most of the sockeye salmon which spawn in the reach between Devil Canyon and Talkeetna. Because access to these side sloughs is highly dependent on mainstem water surface elevations, complete evaluation of this relationship is also necessary.

Side channel habitats, under present conditions, do not provide a significant amount of spawning habitat for salmon. However, based on observations of ADF&G during the 1982 field seasons, it is possible that under with-project flow conditions, some of the side channels may become slough-like. Therefore, evaluation of entrance conditions is necessary to evaluate the potential for side channel salmon spawning under with-project flows.

4.1.1.2 Previous Studies. Previous studies have allowed some evalua tion of entrance conditions to side sloughs and tributaries. Results of those studies and evaluations are presented in the ADF&G 1983 data reports and synopsis report and in the E.W. Trihey (1982a) report on Slough 9 access conditions. In these reports, an access criterion of a minimum water depth

of 0.3 feet for no more than 100 feet was established as a threshold value for salmon entrance to side slough habitats. Using this criterion, as well as observations by ADF&G personnel, the relationship between mainstem flows, indexed to Gold Creek flows, and actual salmon escapement to the side sloughs has been evaluated for several sloughs. These evaluations are based on threshold values of "acute entrance conditions" versus "no inhibition of access. (ADF&G 1983a.)

The E.W. Trihey and ADF&G reports conclude that acute entrance conditions will be encountered at some of the side sloughs at flows of 12,000 cfs up to 16,000 cfs.

Access conditions into Indian River and Portage Creek were evaluated by E.W. Trihey (1983b). For these two tributaries, it was determined that sufficient flows occur in the tributaries to provide adequate entrance conditions at all mainstem flows. In addition, it was determined that under with-project conditions the tributary flows will cause erosion of the streambed profiles (cutting down) sufficient to provide adequate water depth over a sufficient distance to allow salmon access to the tributaries. Additionally, R&M has prepared an evaluation of tributary mouths (R&M 1982). This study determined that tributary flow will cut down the streambed at all but three tributary mouths in the Talkeetna to Devil Canyon reach of the Susitna River. The three tributaries which were determined to have the potential for becoming perched and which have salmon populations are Sherman, Deadhorse and Jack Long Creeks.

At the present time, no evaluation of entrance conditions into side channels has been made. Evaluation of side channels will be conducted, but no entrance problems are anticipated under with-project flow conditions.

4.1.2 Questions to be Answered

The basic question to be answered under Study Task 1 is:

> What range of mainstem flows, as measured at Gold Creek, does not inhibit access to salmon spawning habitats?

This basic question is separated into habitat-specific questions which will be evaluated separately. These are:

1. What mainstem flows do not inhibit adult salmon access to tributaries?

2. What mainstem flows do not inhibit adult salmon access to side sloughs? and

3. What mainstem flows do not inhibit adult salmon access to side channels.

Using the answer to these questions, a further question may be addressed:

> How will with-project flows affect the accessibility to the salmon spawning habitats?

Initially, this question will be addressed utilizing the with-project flow regimes presented in the FERC License Application and the natural flow record for Gold Creek.

Since salmon spawning occurs only during a brief period each year, the flows necessary for providing adult salmon adequate access conditions to spawning habitats will be determined for a specific time period. This flow/time period criterion will then be linked with the flow/time period criteria for other life stages of the salmon in the Susitna to develop a complete year of monthly and weekly flows required to maintain fish habitats.

4.1.3 Study Locations

Studies leading to the evaluation of access conditions have been completed or are continuing at the following specific locations:

Side sloughs:	Sloughs 8A, 9, 11 and 21
Tributaries:	Indian River, Portage Creek and Fourth of July Creek
Side Channels:	Downstream of Slough 21, downstream of Slough 11, upstream of Slough 11, near Slough 10, and at River Mile 114.

Additional observations on access conditions will be obtained for other tributary mouths, side sloughs, and side channels.

4.1.4 Detailed Methodology

4.1.4.1 Data Requirements. Previous studies on access conditions have consisted of the collection of observational data and inference based on the absence or presence of adult salmon upstream of the mouths of side sloughs and tributaries under various flow conditions in the mainstem. Based on these observations, coupled with thalweg profiles and cross-sectional data of some of the slough and tributary mouths, it was determined that chum salmon were able to pass a critical passage reach of less than 100 feet in length with a minimum water depth of 0.3 feet (E.W. Trihey, 1982a). Conditions of less length or greater depth provided chum salmon adequate access conditions into the sloughs. These conditions have been used as the threshold value for accessibility of the spawning habitats by adult salmon.

4.1.4.2 Sampling and Analysis. A more rigorous analysis of threshold access conditions for tributaries, side slough and side channels will be obtained in the manner portrayed in Figure 4-1 (A-C). An index of passage conditions for each study site will be developed based on morphological characteristics of any critical access reach which occurs in the site and an estimate of the percentage of the surface area within the critical reach which is navigable by the salmon. These indices will be developed from thalweg profiles, cross-sections in the critical access reaches, and mainstem rating curves. These will be used to develop an average of water surface elevation for the critical passage reach against mainstem flow. For a series of mainstem flows, the proportion of cross-sectional areas which meet the 0.3 foot depth criterion will be determined. The cross-sectional area proportions will be integrated with thalweg profiles and water surface profiles to determine the proportion of the critical passage reach which meets the less than 100 foot length criterion. In addition, the 0.3 foot minimum depth for less than 100 feet criterion will be verified through documentation of the numbers of fish gaining access under various flow conditions. Verification of the passage criterion will occur principally at the side slough habitats because, under natural conditions, these are the primary habitats where flow conditions which may inhibit access occur. Once verified, the criterion will also be used for evaluating conditions at the tributaries and side channels under with-project flows.

A passage efficiency index for a continuum of mainstem flows will be developed for each study location and for each species. Each species/location index will consist of critical discharge values which define no access and uninhibited access conditions and a curve depicting access efficiency between these critical discharge levels. These indices will then be accumulated by habitat type and by species to define mainstem discharge necessary to provide adequate access conditions. In turn, the habitat indices will be accumulated into one index for all habitats in the Talkeenta to Devil Canyon reach.

FIGURE 4-1A

Evaluation of Conditions For Access : Side Sloughs

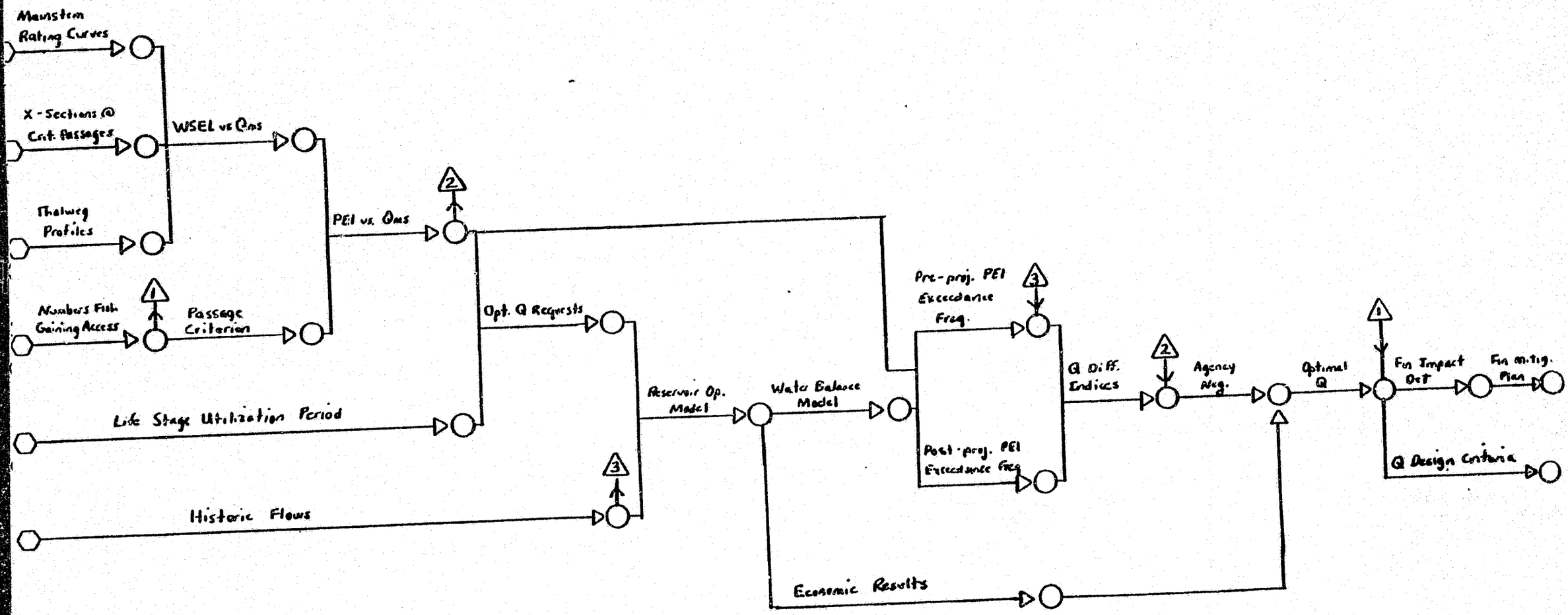


FIGURE 4-1B

Evaluation of Conditions For Access Side channels

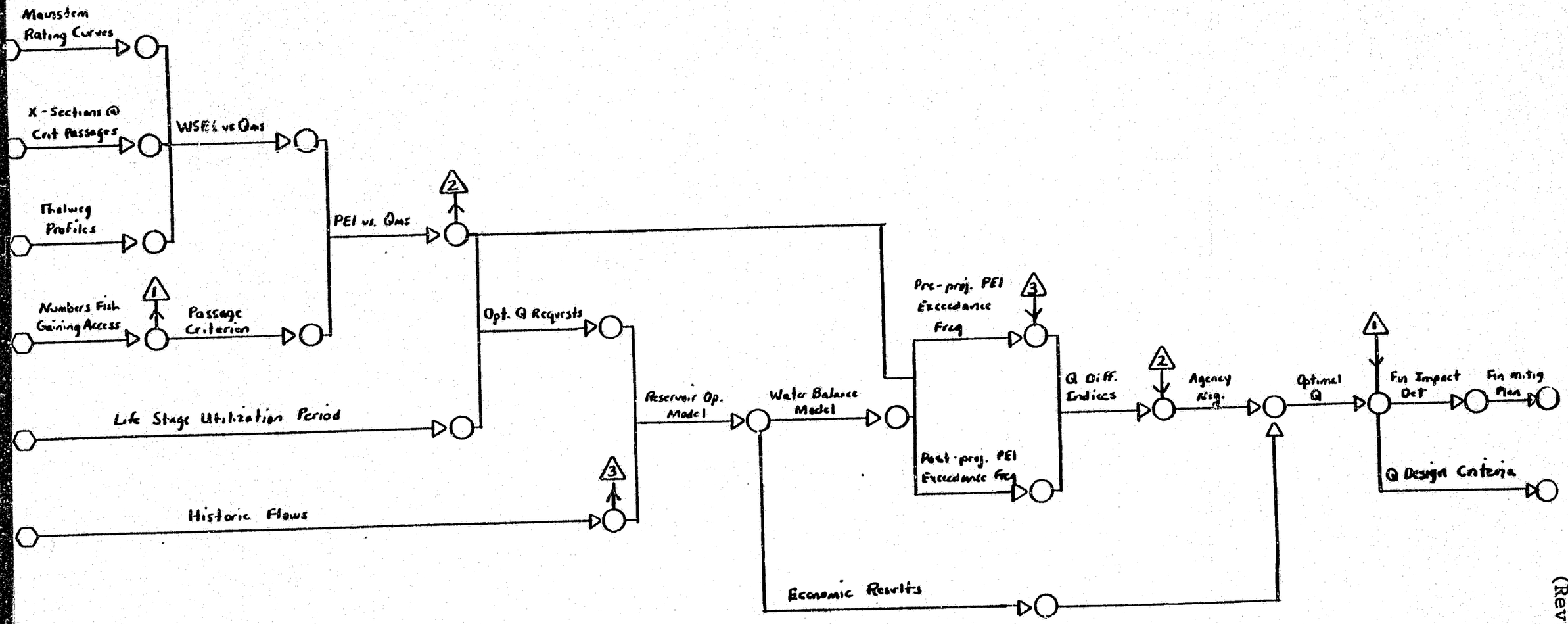


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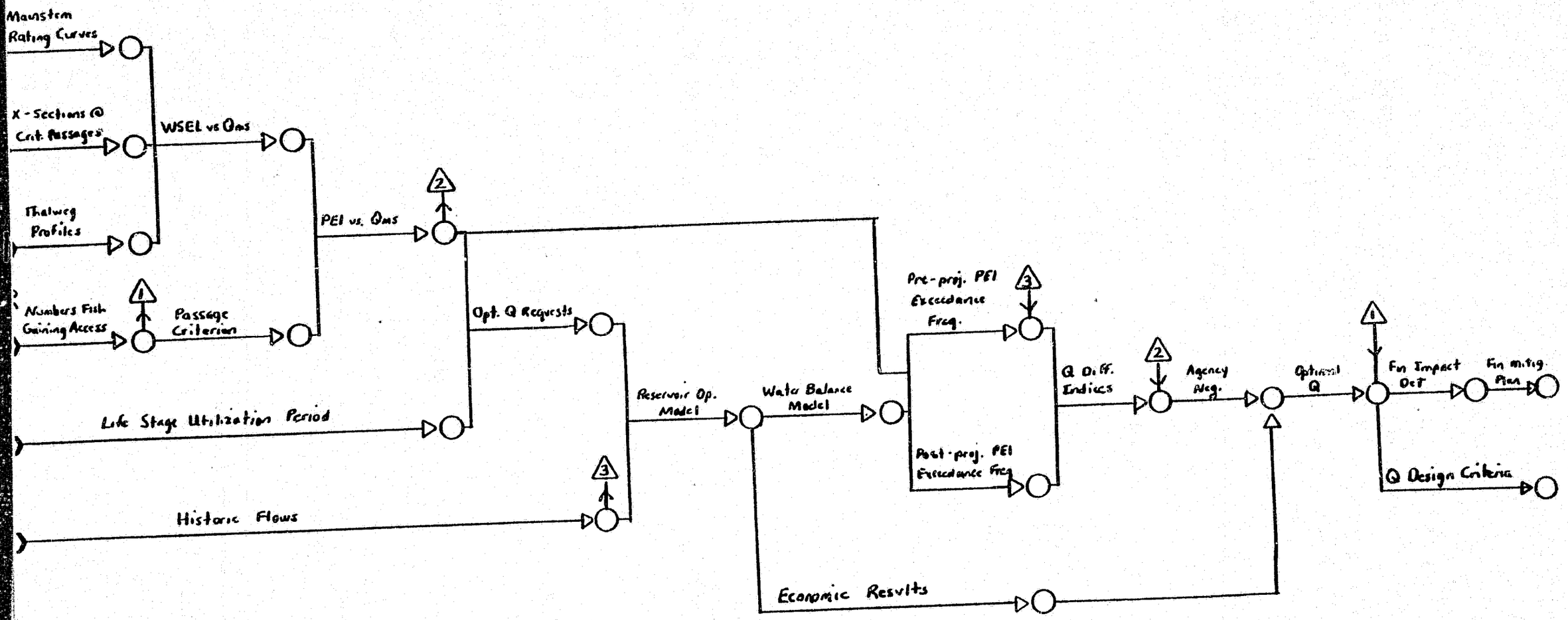
FIGURE 4-1C

Evaluation of Conditions for Access Tributary Mouths



Comparison of natural and with-project flow conditions and the effect on access conditions for the three habitat types will be obtained by comparing the frequency with which the access criteria were met under the 32 year flow record for natural conditions with the frequency with which it is met under simulated with-project regulated flow.

Initial comparison will assume that the flows are regulated as proposed in the License Application. As necessary during the project licensing period and settlement process, additional flow regimes will be tested. A frequency analysis will be used to develop percent exceedance curves for natural and with-project conditions. In the analysis of access conditions, natural and with-project flows will be evaluated only during the period when adequate access conditions are required for each species. This time period will be determined from a life stage utilization diagram which describes when adult salmon are migrating to the spawning habitats.

4.1.5 Data Management and Report Formats

Data necessary to accomplish the analysis and the formats in which they are to be presented are as follows:

1. Mainstem Rating Curves. These data will be presented as water surface elevations collected at the mainstem near the entrance to each of the study locations plotted against mainstem discharge as monitored at Gold Creek.

2. Cross-sections at Critical Passages. These data will be presented as a plot of streambed elevations against distance across the critical entrance passage. Water surface elevations at the cross-section for various mainstem discharges will be plotted on the cross-sections.

3. Thalweg Profiles. These data will consist of streambed elevations at the deepest portion of the study location plotted against

length along the study location in addition to water surface profiles for various discharges in the habitat type and in the mainstem will be plotted on the thalweg profiles.

4. Passage Criterion. Documentation of the passage criterion will consist of a plot of the percent of adult salmon which are successful in gaining access to the spawning area against mainstem flows. Plots will be prepared for each salmon species. These data will be collected for the side slough habitats and will be extrapolated to the other habitats for chum, sockeye, pink, and coho salmon.

5. Life Stage Utilization Period. Documentation of the period when each species arrive at the spawning habitats and are entering the habitats has been accomplished by ADF&G in the course of past field studies. This information will be organized and presented on a bar chart depicting month of year and the start and end of the spawning period.

Results of the analysis will be presented in three formats. The passage efficiency indices will be presented as a graph of the proportion of fish gaining access at various mainstem flows plotted against mainstem flows as measured at Gold Creek. The comparison of natural and with-project flows and the corresponding passage index value will be presented in tabular form for the 32 years of record for appropriate time periods (monthly and weekly). The tabulated information will be reduced to frequencies and presented as a graph of precent of time index values are exceeded versus the passage efficency index.

4.1.6 Coordination of Task Activities

Data to develop mainstem rating curves, cross-sections at critical passages and thalweg profiles have been or will be collected both by ADF&G and R&M. Comparison of water surface elevation in the passage reach versus mainstem flows will be developed by E.W. Trihey and Associates. Determination of the passage criterion has been accomplished using observational data by E.W. Trihey and Associates and will be verified by ADF&G. The above information will be provided to AEIDC who will develop the passage efficiency index versus mainstem flow.

The life stage utilization period has been determined by ADF&G and further refinement of this information will be accomplished by ADF&G. Necessary hydrologic modeling of natural and with-project flow regimes will be provided jointly by Harza-Ebasco and AEIDC.

The comparison of natural and with project access conditions and the frequency analysis will be performed by AEIDC. Evaluation of the significance of the results of the analysis will be performed by Harza-Ebasco.

4.1.7 Schedule and Deliverables

Deliverable	Due Date
1. Mainstem Rating Curves	12/01/83
2. Cross Sections	11/01/83
3. Thalweg Profiles	06/30/84
4. Passage Criterion	
o Observation	Available
o Documentation	08/31/84
5. WSEL in Passage Reach vs Mainstem Flows	06/30/84
6. Life Stage Utilization Period	Available

7.	Passage Efficiency Index	08/31/84
8.	Hydrologic Modeling	Available
9.	Frequency Analysis	04/01/85
10.	Impact Evaluation	06/30/85

4.2 TASK 2 - EVALUATION OF SALMON SPAWNING HABITATS IN SLOUGHS, TRIBUTARY MOUTHS AND SIDE CHANNELS

4.2.1 Background

4.2.1.1 Rationale. The majority of salmon spawning in the Devil Canyon to Talkeetna reach occurs in tributaries. Spawning habitat in these areas will not be impacted by the project if adequate access conditions are provided. The majority of the remaining spawning occurs in side slough and tributary mouth habitats that do respond to discharge. It is anticipated that under with-project conditions some side channels may provide additional spawning habitat under lower mainstem flows and reduced suspended sediment levels while side slough habitat may become less suitable for spawning.

In order to assess impacts to existing spawning habitats and to predict the availability of new spawning habitat, it is necessary to evaluate the physical and water quality attributes of presently utilized spawning habitats. The physical data, combined with observations of utilized area will allow formulation of habitat preference curves which can be used to evaluate impacts to existing habitat or assess availability of new habitat under a variety of project flow scenarios. Information needed to conduct the assessments includes available depth, velocity, substrate and temperature within presently utilized spawning areas, combined with predicted depth, velocity, substrate and temperature under with-project conditions in each of the habitat types being considered.

4.2.1.2 Previous Studies. Physical data, as reported in Appendix A of Volume 4: Aquatic Habitat and Instream Flow Studies of the ADF&G 1982 Phase II Basic Data Reports, 1982, are available for 9 sloughs between Devil Canyon and Talkeetna: Whiskers Creek Slough, Lane Creek Slough, and sloughs 8A, 9, 11, 16B, 20, 21, and 22. IFG-4 analyses were conducted at sloughs 8A, 9 and 21 to describe chum salmon spawning habitat in hydraulic terms (ADF&G 1982a).

The report compares the habitat used to the habitat available. The report showed that slough-spawning chum utilized most available habitat at water velocities and water depths greater than 0.2 ft. The unusually low water during the 1982 spawning season caused all depths and velocities to fall within the acceptable spawning range. The preferred spawning substrate was gravel/rubble and rubble/cobble.

Sufficient physical data to describe the characteristics of the habitat utilized by salmon and to determine the preferences were not obtained during 1982. This was due to the low mainstem discharge which in turn limited the range of available habitat conditions. In addition, ADF&G did not feel a sufficient number of data points were collected at spawning redds to accurately define spawning preferences. A limited number of observations in side channel spawning areas indicated that similar spawning habitats (to sloughs) were being utilized (ADF&G 1983a).

Temperature data have been collected from many habitats, as reported in the ADF&G Aquatic Habitat and Instream Flow report of 1982. Surface water temperatures during the open water season were monitored continuously at six mainstem locations (RM 103, 113, 120.7, 126.1, 130.8 and 140.1); six sloughs (8A, 9, 11, 16B, 19 and 21) and two tributaries (Indian River and Portage Creek). Continuous records of intragravel water temperature also were obtained for the above six sloughs.

Instantaneous surface and intragravel temperatures are reported for chum salmon spawning areas and a variety of other slough habitats between Devil Canyon and Talkeetna (ADF&G 1983c).

4.2.2 Questions to be Answered

The basic question to be answered under Study Task 2 are:

> How does mainstem discharge and temperature affect salmon spawning habitat in the Susitna River?

This basic question may be separated into habitat-specific questions as follows:

1. How does the available salmon spawning habitat in side-sloughs respond to mainstream flow and temperature?

2. How does the available salmon spawning habitat in tributary mouth habitats respond to mainstem flow and temperature?

3. What range of mainstem discharge and temperture will provide suitable salmon spawning habitat in side channels and how does this habitat respond to mainstem flow and temperature?

4. At what range of mainstem discharge and temperature will habitat in the mainstem become available for salmon spawning?

Using the answers to these questions, a further question may be addressed:

> How will with-project flows and temperatures affect spawning habitats within the Susitna River?

As described in Section 3.0, answers to the habitat-specific questions will be used to generate relationships between mainstem discharge/temperature and salmon spawning habitats for the Susitna River between Devil Canyon and Talkeetna. These relationships will be applied to these specific periods when salmon spawning occurs. The relationships will also enable evaluation of alternative flow regimes, a comparison with-project economics, determination of a recommended flow and temperature regime and the associated effects to the aquatic system.

4.2.3 Study Locations

Studies of salmon spawning habitat have been conducted at the following locations: Sloughs 8A, 9, 11, and 21; side channels located just downstream of slough 21, upstream of slough 11, downstream of slough 11, upstream of slough 10, and at R.M. 114; and at the mouth of Fourth of July Creek.

4.2.4 Detailed Methodology

4.2.4.1 Data Requirements. The analysis of the response of spawning habitats to mainstem dicharge and temperature changes requires several sets of data. These are identified below and are shown on Figures 4-2 (A-D).

1. Historic discharge data are required to evaluate how the natural regime affects the spawning habitats as well as for developing predicted flow events under the with-project conditions.

2. Life Stage Utilization Period data are necessary to define the specific period within the annual cycle in which spawning occurs.

3. Mainstem discharge vs habitat discharge data are necessary to define how the conditions in each specific habitat are dependent upon conditions in the mainstem. These data become the critical link in determining the effects of altered mainstem flow regimes on the physical conditions in the spawning habitats.

4. Physical data are required to demonstrate how the physical conditions in the habitat types respond to various discharges. The data required include depths, velocity and substrate data to calibrate the IFG-4 hydraulic model.

5. Depth, velocity substrate and temperature data collected at salmon spawning sites are needed to determine the types of habitat conditions utilized by the fish.

6. The location of salmon spawning sites (redds) vs location of groundwater upwelling is necessary to determine the relative importance of groundwater upwelling to the selection of spawning sites.

7. Surface and Intragravel water temperature are necessary to determine if spawning site selection is correlated with temperatures in the mainstem.

Evaluation of salmon spawning habitat in sloughs will be expanded to encompass other habitats. The effort will focus on providing habitat utilization curves for chum, pink, coho and sockeye salmon. These curves will be combined with the analysis of conditions under various flow regimes to predict changes in availablity of spawning habitat in side slough, side channel and tributary mouth habitats.

The data necessary to accomplish this analysis and the formats in which they are needed are as follows:

(a) Habitat Availablity Data. These data consist of histograms showing the frequency distributions of water depth, water velocity and substrate composition under various discharges.

(b) Habitat Utilization Data. These data consist of histograms showing the frequency distribution of water depth, water velocity and substrate actually utilized by each species of spawning salmon.

(c) Habitat Preference Data. Habitat preference for each species is obtained by over-laying habitat availability histograms with

habitat utilization histograms to identify preferred depth, velocity and substrate.

(d) Hydraulic Modeling Results. Hydraulic models (i.e. IFG-2 and IFG-4) are used to describe the depth, velocities and substrate present in the stream channel at given flows. The habitat present in the channel at each selected flow is then compared with the spawning habitat preference data to quantify the amount of useable spawning habitat in the modeled channel. The results are presented as an index, weighted useable area (WUA), at the different flows to evaluate the change in useable habitat with changing flows.

The interrelationship of the analyses are shown on Figure 4-2 (A-D).

4.2.5 Report Formats

The spawning habitats report will contain sections on:

(1) Characteristics of presently utilized spawning habitat;

(2) Description of methods and analysis used to develop habitat criteria;

(3) Presentation of habitat criteria in comparison to other studies;

(4) Quantification of existing habitat; and,

(5) Changes in habitat under different flows.

FIGURE 4-2 Evaluation of Conditions For Planning: Side Sloughs

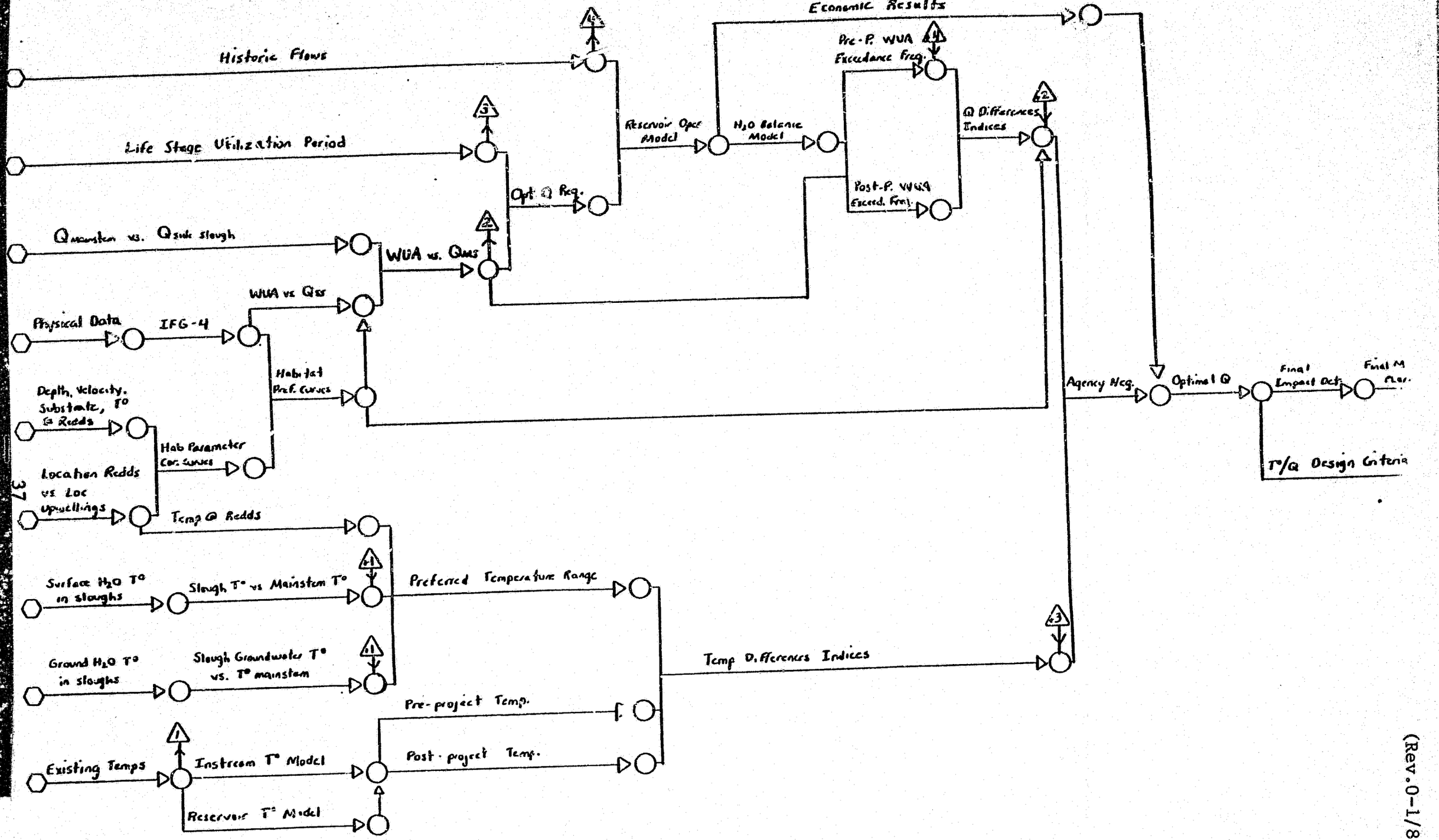


FIGURE B

Evaluation of Conditions For Spawning: Side Channels

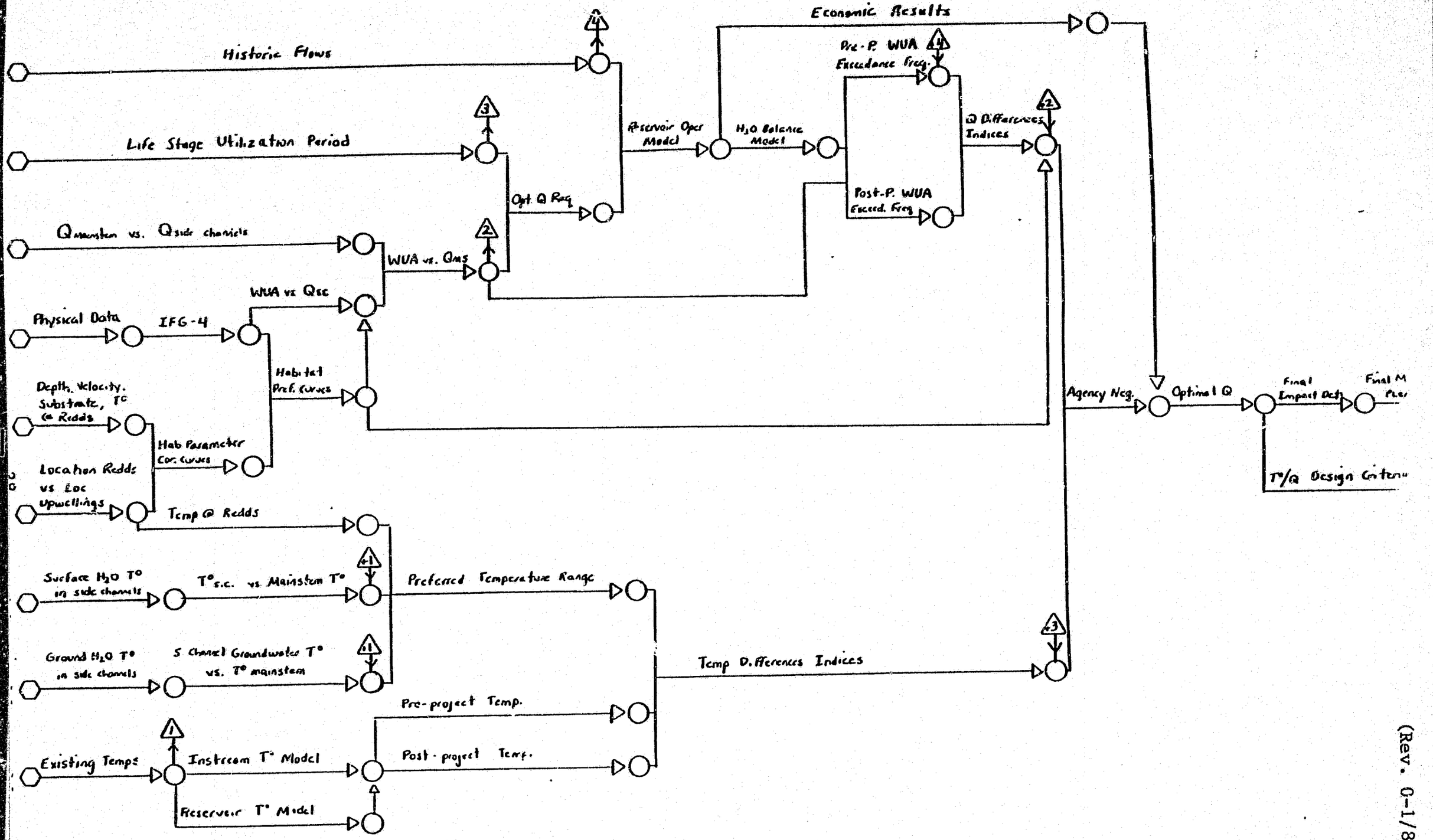


FIGURE 4-2

Evaluation of Conditions for Spawning: Tributary Mouths

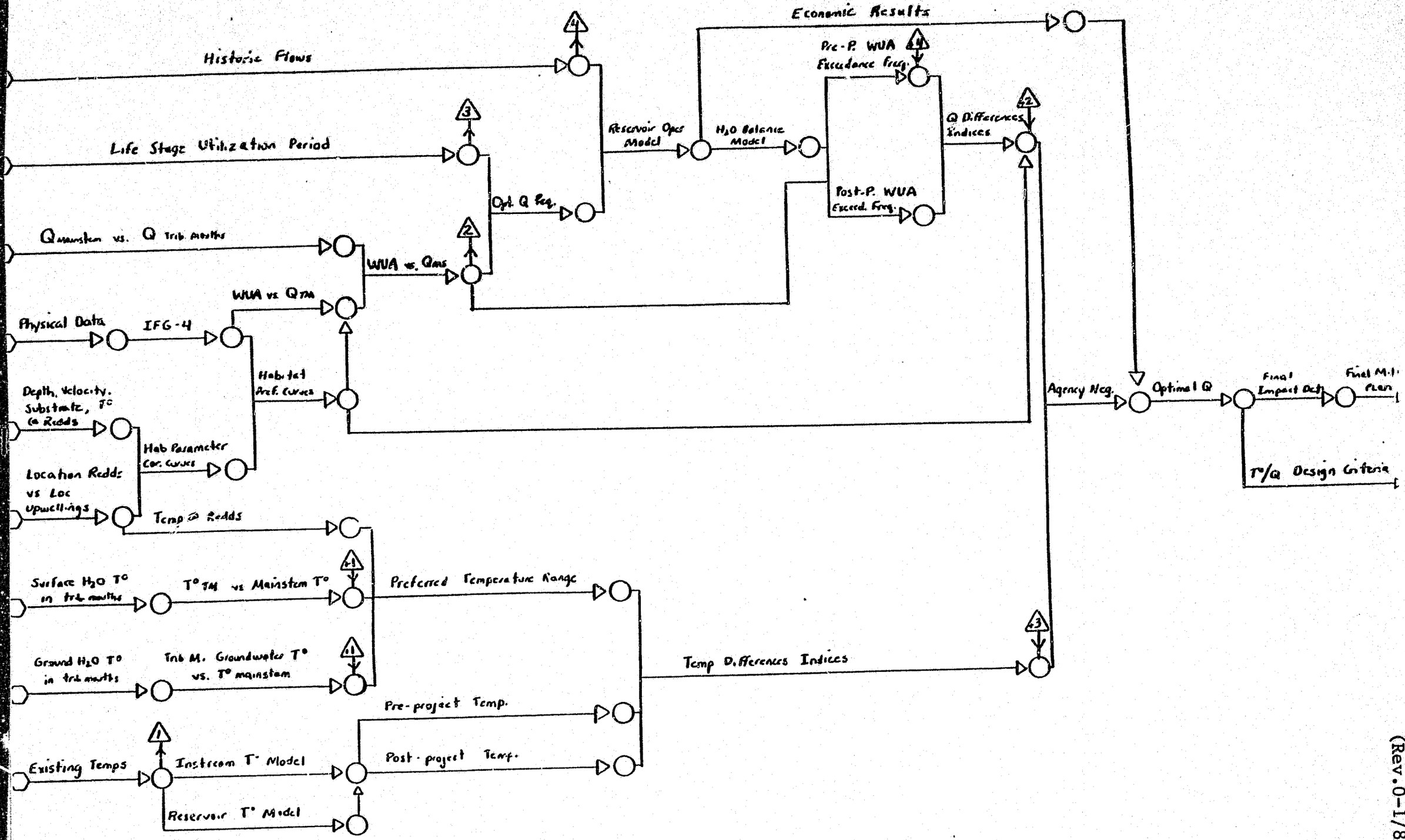
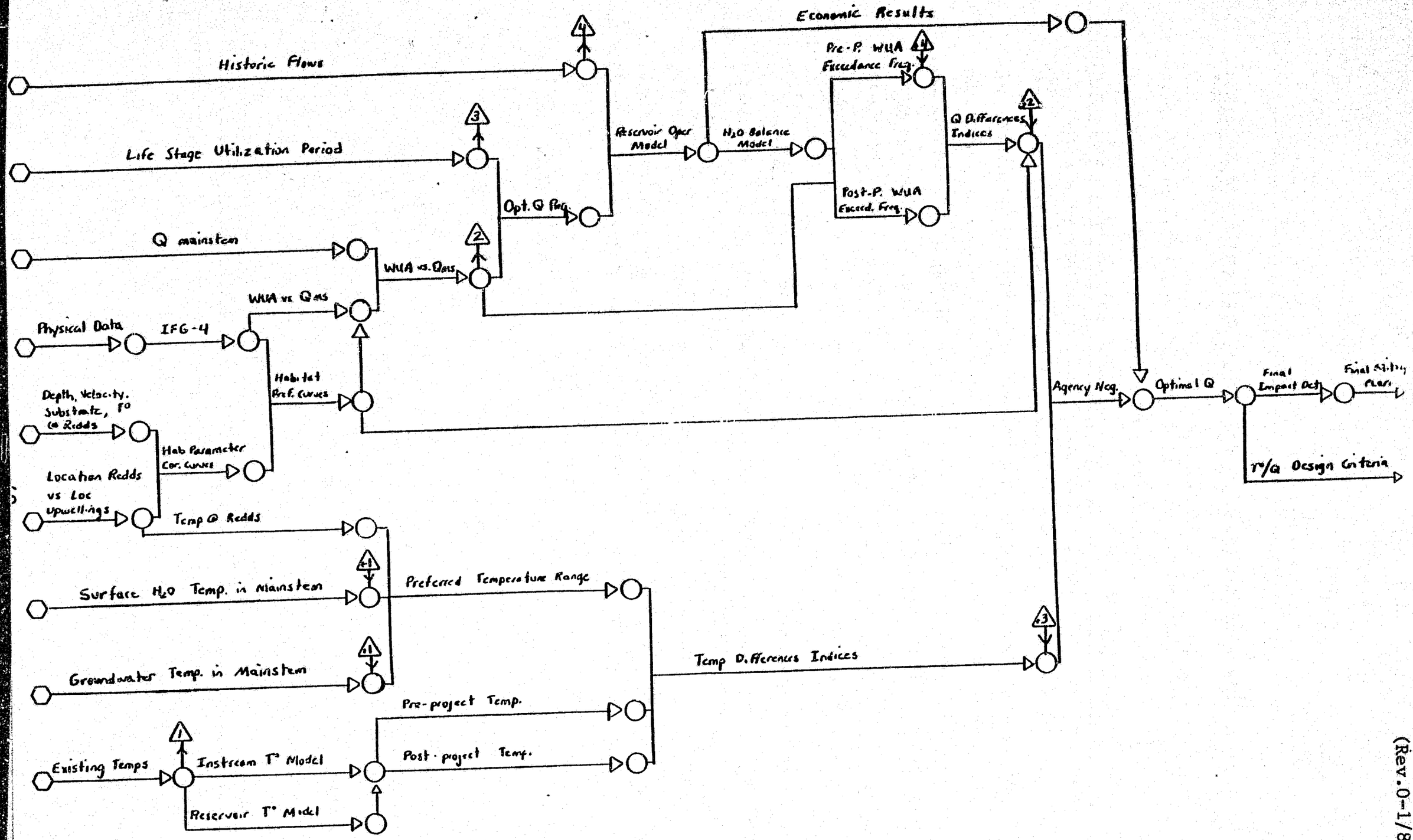


FIGURE 4

Evaluation of Conditions For [illegible]ning: Mainstem



4.2.6 Coordination Among Participants and Other Activities

Data to be used in the analyses previously described were collected primarily by ADF&G. These data consist primarily of the habitat specific hydraulic data and the data collected at the salmon spawning sites. The hydraulic data for defining the available habitats will be utilized by E.W. Trihey to calibrate the IFG-4 hydraulic model. Results of these models will be integrated with habitat utilization and preference curves by ADF&G to provide comparision of weighted usable areas (WUA) vs mainstem flow. The tabulation of weighted useable areas will be used by AEIDC to evaluate alternative flows and to analyze the effects of the recommended flows. Woodward Clyde will then utilize these results to update the mitigation program.

Harza-Ebasco will be completing analysis of temperature releases from the reservoir using the DYRESM temperature model. Results of this modelling effort will be used by AEIDC to evaluate the instream temperatures using the SNTEMP model. Results of the SNTEMP model inturn will be used by Harza-Ebasco to predict the timing and progress of ice formation in the Devil Canyon to Talkeetna reach using the ICECAL model.

4.2.7 Schedule and Deliveables

Deliveiable	Due Date
1. Life Stage Utilization Period	Available
2. Mainstem Discharge vs Habitat	6/30/84
3. IFG-4 Calibration	1/1/84
4. WUA vs Mainstem Discharge	8/31/84
5. Habitat Relationships	8/31/84
6. Comparison of Alternative Flows	3/31/85
7. Recommended Flows	4/01/85

4.3 TASK 3 - EVALUATION OF INCUBATION HABITAT IN SLOUGHS, SIDE-CHANNELS, TRIBUTARY MOUTHS, AND MAINSTEM

4.3.1 Background

In order to evaluate project impacts on incubation, the following information is required: 1) the physical and chemical requirments for successful incubation; 2) how these physical and chemical requirements will be altered by the project; and, 3) how incubation success will be affected by these changes. Parameters that influence incubation success include water temperature and oxygen supply in the redd. The adequacy of the oxygen supply is determined by the oxygen content of the interstitial water, the permeability of the gravels and the flow rate through the gravels. The incubation temperature is controlled by the source of the incubation water. In the side sloughs used for spawning, the main source of incubation water appears to be groundwater upwelling in the floodplain alluvium. Mainstem chum salmon spawning areas also may be controlled by groundwater upwelling. The incubation temperature in spawning areas at tributary mouths is controlled by tributary flow, at least during the early incubation period. During the winter months, flow may be either from the tributary or the mainstem Susitna.

Under with-project conditions the two incubation parameters most likely to change are the quantity of water and the temperature regime in presently utilized incubation habitats. It is likely that some presently utilized areas, such as parts of some of the side sloughs, will be dewatered by the lower mainstem flows. It is anticipated that groundwater flow in most of the side sloughs will continue, although the discharge may be lower and the location of upwelling areas may shift downstream. The tributary mouths should not be affected where the main source of water is the tributary flow.

Mainstem and side channel spawning areas may or may not be affected by the reduced flow, depending on their location in relation to the project water level.

Incubation temperatures in areas controlled by groundwater should not change under with-project conditions, thus the temperature is side slouhs should not be changed. However, if the project causes side sloughs to overtop because of the ice-related staging, the incubation temperature could decrease.

Temperatures at tributary mouths should be within the naturally occurring range in the fall and be near the temperature of the source water (0°C if tributary flow, or mainstem temperature if mainstem flow) for the remainder of the incubation period.

Mainstem incubation areas will be controlled by the mainstem temperatures regime, which is anticipated to remian warmer than present into the fall, then approach 0°C by early January (ACRES 1983).

4.3.1.2 Previous Studies. In the Devil Canyon to Talkeetna reach, most salmon incubation occurs in tributaries and will not be affected by the project. The second most important incubation habitat area within this reach is in the side sloughs.

Data on the number of spawning salmon and fecundity of these slough-spawning salmon are available. Estimates of the number of emergent fry are available for sloughs. Some incubation occurs in tributary mouths and mainstem areas, although this use is unquantified, it is considered to be low compared to tributaries and sloughs.

The laboratory incubation study performed by USFWS (Wangearl and Burger, 1983) and in situ incubation information in the ADF&G Winter Studies Report (1983c) provides baseline information on present developmental rates of salmon embryos during incubation. The predicted with-project temperature

regime in the various habitats will indicate potential changes to development rates and indicate potential impacts because of these changes.

ADF&G field investigations provide surface and intragravel temperature, dissolved oxygen, specific conductance and pH data for incubation habitat in sloughs between Devil Canyon and Talkeetna. Continuous surface and intragravel temperature are available from February to May 1982 and from August to October 1982 at ten locations (ADF&G, 1983b). In 1982-83, surface and intragravel temperatures, dissolved oxygen, specific conductance and pH were measured at sloughs 21, 11, 9 and 8A. In the tributary mouths, continuous surface water temperature data are available for June to October 1982 from Indian River and Portage Creek (ADF&G, 1983b). In the mainstem, continuous surface water temperature data are available for ten locations from May to October for 1982 and 1983. Winter surface water temperatures are essentially 0°C from about October to April each year. Intragravel temperature was measured at various mainstem spawning locations in September 1982 (ADF&G, 1983b).

4.3.2 Questions to be Answered

The principal question to be answered by the Task 3 study is:

How does mainstem discharge and temperature affect salmon egg incubation in the various habitats utilized by salmon for spawning?

As with the previous tasks this principal question may be separated into habitat type-specific questions as follows:

1. How does mainstem discharge and temperature affect salmon egg incubation in side slough habitats?

2. How does mainstem discharge and temperature affect salmon egg incubation in tributary mouth habitats?

3. In areas which become suitable for salmon spawning in side channels under with-project conditions, at what flows and temperatures will conditions become suitable for successful incubation of salmon eggs?

4. In areas which become suitable for salmon spawning in the mainstem under with-project conditions, at what discharges and water temperatures will conditions become suitable for successful incubation of salmon eggs?

Again, using the answers to these questions, the relevent question becomes:

What discharge and water temperature will provide adequate conditions to maintain salmon egg incubation success at rates equivalent to existing production and how will egg incubation success respond to alternative with-project discharge and temperature regimes?

As described in Section 3.0, answers to the habitat-specific questions will be used to generate relationships between the incubation of salmon eggs and discharge/temperature regimes in the Susitna River between Devil Canyon and Talkeetna. These will then be used to evaluate alternative operating regimes for the project and to develop a recommended discharge and temperature operating regime and to evaluate the effects of the recommended regime on salmon egg incubation.

4.3.3 Study Locations

Studies leading to the evaluation of incubation habitat requirements have been conducted, or are being conducted at the following locations:

Side Sloughs: 6A, 8A, 9, 11, 20, 21

Tributary Mouths: Mouth of 4th of July Ck, Mouth of Lane Ck, mouth of Indian River and mouth of Portage Creek.

Side Channels: Mainstem II (RM 114.4), 4th of July Ck side channel, Slough 10 side channel, above Slough 11, below Slough 11, Slough 21 side channel.

4.3.4 Detailed Methodology

4.3.4.1 Data Requirements. Estimates of the number of spawning salmon, average adult female fecundity and the number of emergent fry in a particular slough will allow calculation of the survival rate of the salmon eggs through the incubation period. This information will be coupled with physical habitat data to describe the general characteristics of the habitat which might affect the survival rates. Physical data which will be used include surface and intragravel water temperature, and estimates of the areal extent of groundwater upwelling sites as indicated by the number and extent of observed open water leads during the winter months. Results of the physical data collection at specific spawning habitats coupled with determination of the time at which fry emerge from these sites will enable estimation of the development rate of the embryos. This information can then be compared with the results of the USFWS experimental incubation study (USFWS, 1983).

An additonal field experiment will enable documentation of the relationship between physical parameters and the development and survival rates of the embryos. Fertilized salmon eggs will be placed in Vibert boxes (plastic cage-like boxes which provide for adequate circulation of water) and buried in the gravel at various locations in sloughs 21 and 11 and in Indian River. Six boxes, each containing approximately fifty eggs, will be buried at a single location. Periodically, boxes will be removed and the embryos preserved for evaluation of the development stages reached by the embryos, and to estimate the number of eggs still surviving. At the time boxes are removed, physical and chemical data will be collected through standpipes driven into the substrates at random locations in the sloughs. Water quality parameters to be measured will include dissolved oxygen, pH,

conductivity and surface and intragravel water temperatures. Continuous recordings of surface and intragravel temperatures will also be collected throughout the studies.

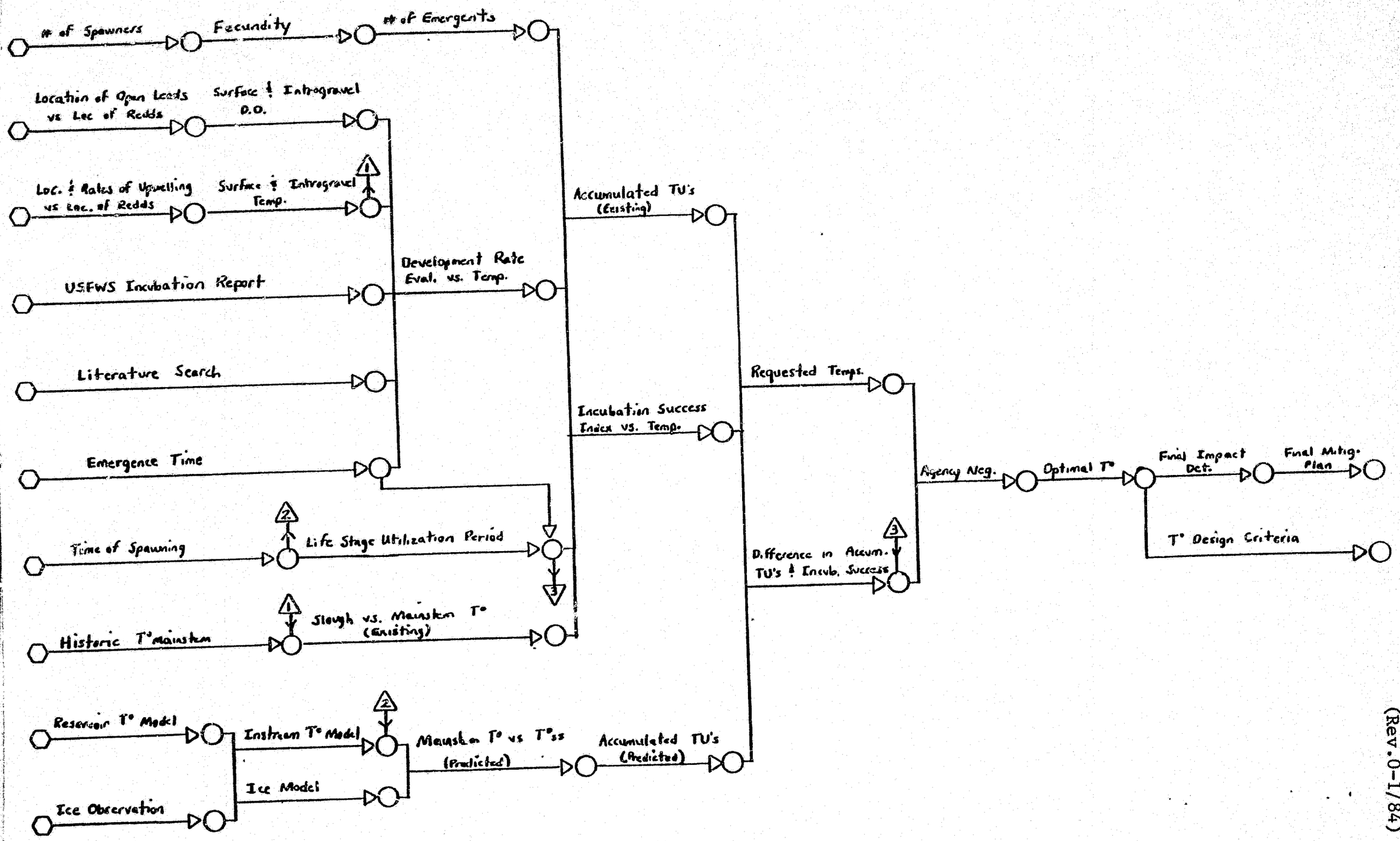
4.3.4.2 Sampling and Analysis. Sampling procedures are described as part of the identification of data requirements. Analysis of the data will include determination of the Temperature Units (TU) accumulated by the embryos through time for comparison with the results of the USFWS study. Development stage acheived at particular TU increments will be used to determine developmental rates, survival rates (percent of the embryos surviving through time) and will be compared with the TU accumulation rate. Comparison of developmental and survival rates between sites within the slough and tributary habitats will be used to estimate the effects on the salmon embryos of various conditions within a slough. In addition, a similar comparison of results obtained between sloughs will be conducted.

Results of these analyses will identify the habitat conditions which provide for the highest survival rates of the salmon eggs under natural conditions. These results will be compared with the results of the USFWS study and with the predictions of surface water and groundwater temperatures and discharges resulting from operation of the project. These comparisons will allow estimates of the effects of the project on incubation of the salmon eggs. In addition, results will be extrapolated to other habitat types (mainstem, side channel) to determine the potential for expanding the productivity of salmon as a result of the project.

The process by which this analysis will be completed, including identification of the data requirements and analytical results, is presented in Figures 4.3 (A-D).

FIGURE 4-3

Evaluation of Conditions During I[illegible]ation : Side Sloughs



(Rev. 0-1/84)

FIGURE 4-3

Evaluation of Conditions During Incubation : Side Channels

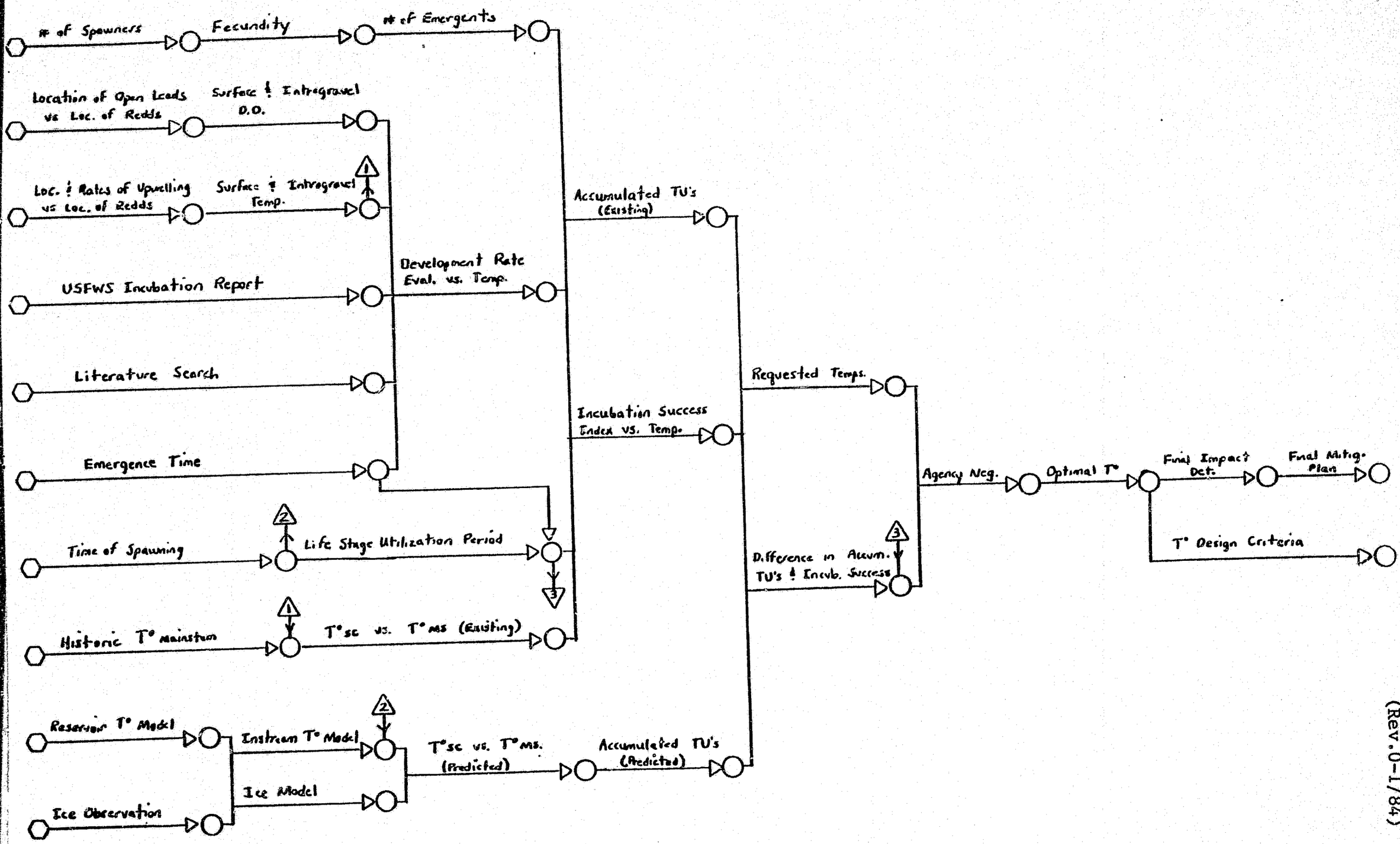


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FIGURE 4-3C

Evaluation of Conditions During Incubation : Tributary Mouths

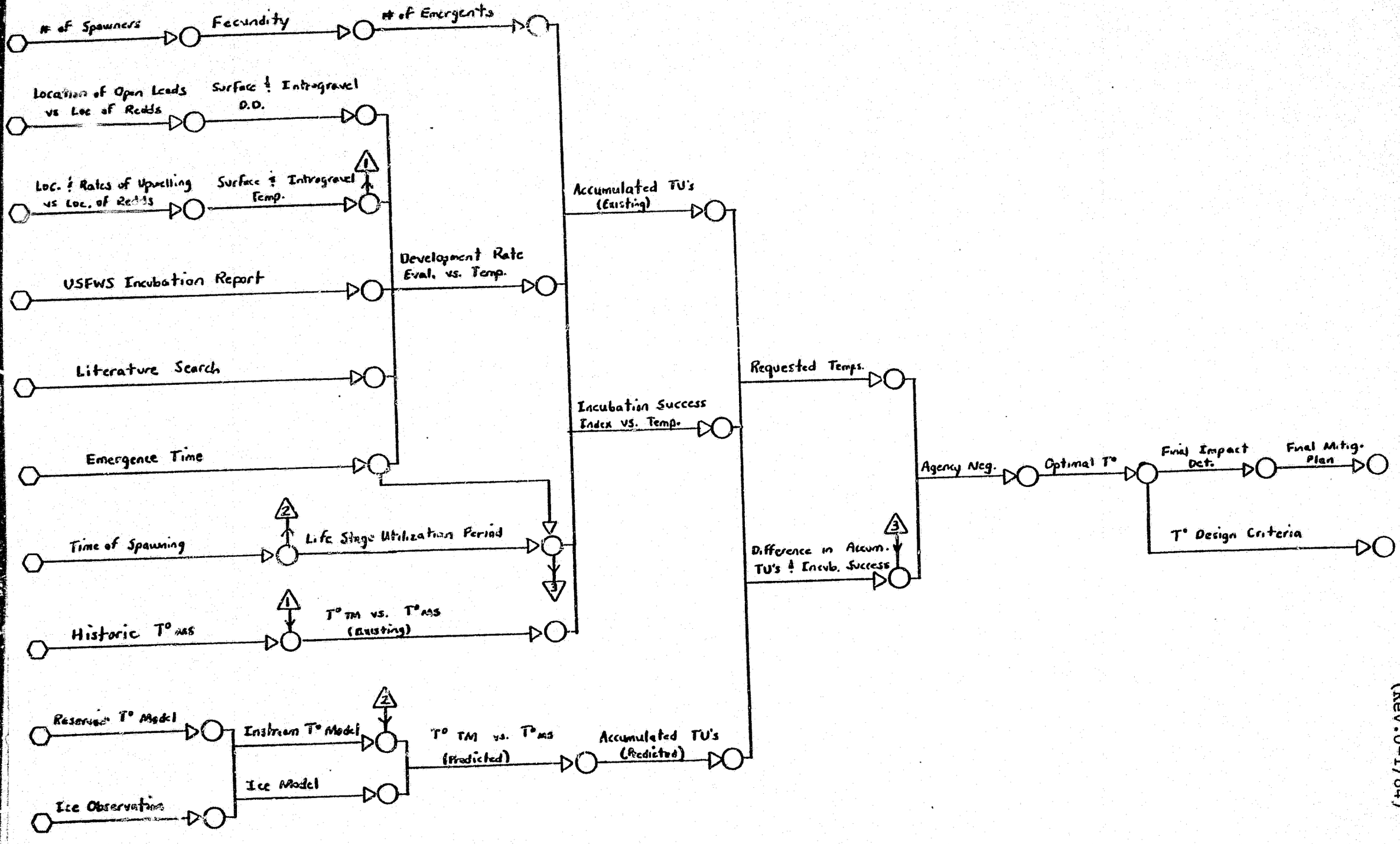

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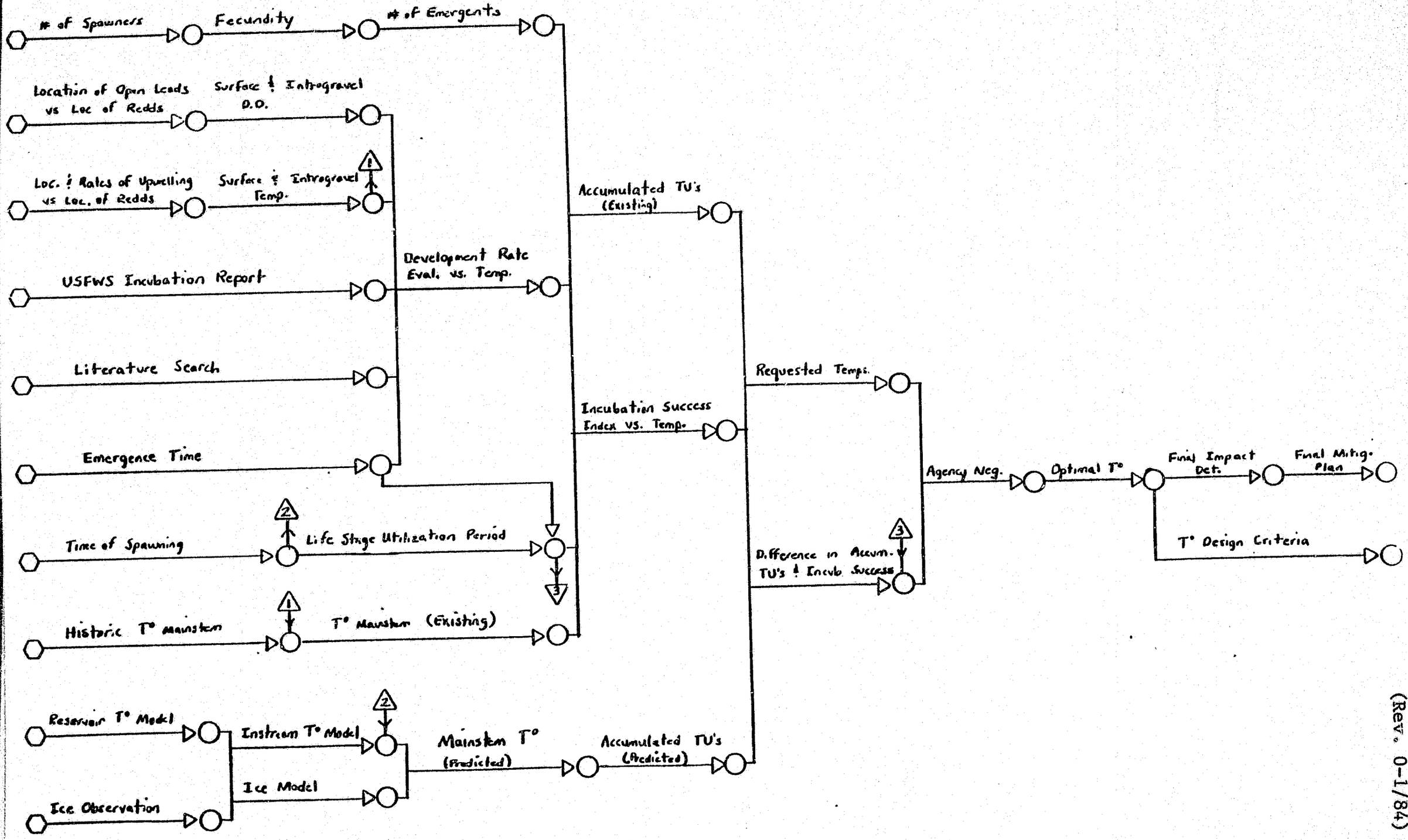
FIGURE 4-3

Evaluation of Conditions During [illegible]ation : Mainstem



(Rev. 0-1/84)

4.3.5 Report Formats

The report describing the results of the incubation studies will contain the following sections:

1. Characteristics of the conditions during which incubation occurs

2. Description of the methods used to collect and analyze the data to develop habitat and survival indices;

3. Presentation of the results of the data collections and analyses, including analysis of the variability observed or expected under natural habitat conditions;

4. Discussion of these results to include comparison with other studies and definition of the habitat criteria necessary to assure conditions suitable for incubation of the embryos; and,

5. Discussion of how the incubation of salmon embryos may be altered under different flow and temperature conditions.

4.3.6 Coordination Among Participants

Field data will be collected through the incubation period and initial reduction and analysis of the data will be performed by ADF&G. This analysis will consist of correlating survivorship and development rates with habitat conditions. AEIDC will use these data and results of the water temperature modeling effort to compare natural and with-project conditions and the potential effect on survivorship and development rates of the embryos. Harza-Ebasco will provide results of the reservoir temperatures and ice models and the mainstem ice model as needed.

4.3.7 Schedule and Deliverables

Deliverables	Due Date
1. Escapement Estimates and Fecundity	12/15/83
2. USFWS Incubation Report	Available
3. Literature Search	2/20/84
4. Life Stage Utilization Period	Available
5. Incubation Success Index	8/31/84
6. Insteam Temperature Relationships	8/31/84
7. Evaluation of Alternative Regimes	3/31/85
8. Final Impact Assessment	6/30/85

rear in similar habitats but show a preference for upland sloughs, side sloughs and side channels associated with a tributary (ADF&G 1983a). Sockeye juveniles showed a preference for upland sloughs and side sloughs without a tributary, with secondary use of side channels and side sloughs with tributaries. Data on habitat use by juvenile chum salmon indicate little habitat preference among low-velocity areas, but the low number of observations of utilized habitat limited the analysis (ADF&G 1983a).

A habitat quality index was developed for each of the four species (ADF&G, 1983a). These indices, which present the response of the juvenile habitats to various mainstem flows, were evaluated at Goose Creek/Slough, Rabideaux Creek/Slough, Birch Creek/Slough, and Whiskers Creek/Slough for chinook; at Sunshine Creek/side channel, Birch Creek/Slough, and Lane Creek/Slough 8 for coho; at Birch Creek/Slough, Slough 8a and Slough 19 for sockeye; and, Birch Creek/Slough, Slough 6A, and Lane Creek/Slough 8 for chum. Mainstem flows for which these habitat indices were evaluated ranged from 12,500 to 27,500 cfs, measured at Gold Creek, and 35,000 to 70,000 cfs as measured at Sunshine.

4.4.2 Questions to be Answered. The basic question to be answered under Study Task 4 is:

How do mainstem discharge, temperature and turbidity affect juvenile rearing habitats in the Susitna River?

Habitat type specific questions for which the answers will enable response to the basic question are as follows:

1. How does juvenile salmon rearing habitat in side sloughs respond to mainstem discharge temperature, and turbidity?

2. How does juvenile salmon rearing habitat in side channels respond to mainstem discharge, temperature and turbidity?

4.4 TASK 4 - EVALUATION OF REARING HABITATS INCLUDING REDISTRIBUTION OF JUVENILES TO SLOUGHS, SIDE-CHANNELS, TRIBUTAY MOUTHS AND TRIBUTARIES

4.4.1 Background

4.4.1.1 Rationale. The juveniles of four species of Pacific salmon (chinook, coho, sockeye and chum) are known to rear at least for some period in habitats influenced by the mainstem Susitna River. Pink salmon juveniles outmigrate with little or no freshwater rearing. During the open water rearing season, salmon juveniles utilize low velocity areas on the lateral margins of the active floodplain. These areas are subjected to reduced surface area, dewatering or isolation from the main river when mainstem flows are reduced.

Habitat parameters that influence juvenile rearing include velocity, depth, substrate characteristics, availability of cover and temperature. Cover can be in the form of overhead or instream cover; turbidity can also function as cover. It is anticipated that with-project flows will effect all of these habitat parameters to various degrees.

In order to assess project impacts on rearing salmon, it is necessary to understand (1) the habitat requirements of rearing salmon by species, (2) the distribution and amount of rearing habitat available under present conditions, and (3) changes in habitat availability (both distribution and quantity) under with-project flows.

4.4.1.2 Previous Studies. Preliminary information is available on hab itat requirements of the four salmon species that rear in the Susitna River (ADF&G, 1983a; ADF&G, 1983d). Chinook juveniles rear in low velocity lateral habitats such as tributary mouths, side sloughs, upland sloughs and side channels (ADF&G, 1983a). Available data do not show preference for any particular habitat (ADF&G, 1983a) although recent information suggests that side channels are heavily utilized at times and turbidity can be an important cover feature (D. Schmidt, ADF&G, Pers. Comm.). Coho Juveniles

3. How does juvenile salmon rearing habitat in upland sloughs respond to mainstem discharge, temperature and turbidity?

4. How does juvenile salmon rearing habitat at turbidity mouths respond to mainstem discharge, temperature and turbidity?

5. How does juvenile salmon rearing habitat in the mainstem respond to discharge, temperature, and turbidity?

The responses to these questions, taken together as a synthesis of the effects of mainstem discharge, temperature and turbidity on juvenile salmon rearing habitats, will be used to respond to the further question:

At what range of discharge and temperature conditions in the Susitna River will adequate juvenile rearing habitat exist to maintain production of salmon and how will with-project discharge, temperature and turbidity affect juvenile rearing habitats?

As described in Section 3.0, answers to the habitat- specific questions will be used to generate the relationships between juvenile salmon rearing habitats and mainstem discharge, temperature and turbidity. These in turn will be used to evaluate the alternative discharge regimes described in the License Application as well as other appropriate regimes to develop a recommended flow regime and an evaluation of the effects of that flow regime on juvenile salmon.

4.4.3 Study Locations

Side Channels:
- Mainstem II
- Slough 10 Side Channel
- Above Slough 11
- Below Slough 11
- Slough 21 Side Channel

Sloughs:	Rabideaux Creek/Slough Whiskers Creek/Slough Sloughs 6A, 10, 11, 19, 20
Tributaries:	Rabideaux Creek Whiskers Creek Gold Creek

4.4.4 Detailed Methodology

4.4.4.1 Data Requirements. The evaluation of the response of juvenile salmon rearing habitats to mainstem flow and temperature regime involves two types of analyses. The first involves utilization of the IFG-4 hydraulic models and the PHABSIM habitat simulation model. The second analysis makes use of an incremental analysis based on mainstem flow vs. surface area of the habitat study site weighted by catch-per-unit-effort.

The IFG-4/PHABSIM modeling effort for juvenile salmon habitats requires the same hydraulic data for calibrating the model as described for the analysis of spawning habitats. The result of the spawning habitat hydraulic models will be also used for the juvenile salmon habitat analysis. Preference curves will be developed relating depth, velocity, substrate and cover to the presence of juvenile salmon through a correlation of catch-per-unit-effort with the physical date from randomly selected sampling sites within the IFG-4 study areas.

Additional data required for the analysis include mainstem discharge vs. habitat type discharge relationships, mainstem water temperature vs. rearing habitat water temperature, timing of the utilization of the habitats by the juveniles and the historic natural discharge in the mainstem.

The second type of analysis requires similar data sets except that data to calibrate the hydraulic models are not needed. However, surface area of the habitat study sites vs. mainstem flow is required.

4.4.4.2 Sampling and Analysis. The IFG-4/PHABSIM analysis of the juve nile habitat repsonses to mainstem flow will proceed in a manner similar to that described for the spawning habitat analysis. This analysis will provide the following results:

1. Histograms of the frequency of occurrence of depths, velocities, substrates and cover availability within the study areas;

2. Histograms of the distribution of juvenile salmon, by species, found at different depths, velocities, substrates and cover availability densities;

3. Preference curves for juvenile species for various depths, velocities, substrates and cover densities; and,

4. Weighted useable areas for each juvenile species in the various habitat study areas.

The weighted useable areas will then be accumulated by habitat type for each species to provide relationships between mainstem discharge and weighted useable area for each species and habitat type available in the reach between Devil Canyon and Talkeetna. The weighted useable areas for the habitat types will then be accumulated for each species to represent scalar relationships between juvenile rearing habitats in the river and mainstem discharges.

A similar analysis will be conducted for those habitat types and study areas for which hydraulic modeling has not been performed. The results of this analysis will include a habitat quality index weighted by the surface area of the habitat and the frequency of occurrence (catch per unit effort) of juvenile salmon within the habitats. As with the previous analysis, the indices will be first accumulated to achieve habitat quality indices for each habitat type and then accumulated for the river as a whole.

The results of the two analyses, both based on surface area, will then be integrated to provide an index of how the juvenile rearing habitats for each species respond to mainstem discharge. The relationship between data collection and analysis is shown on Figure 4.4 (A-E).

Determination of the required flows and temperatures to maintain juvenile rearing habitat, evaluation of alternative with-project flows regimes and assessment of the effects of the recommended flow regime will proceed as outlined in Section 3.0.

4.4.5 Report Formats

The Reports describing the results of the juvenile rearing habitat studies will include the following:

1. Juvenile Salmon habitat relationships will be discussed in the Instream Flow Requirements Report. This will provide analysis of how juvenile rearing habitats respond to mainstem discharge and temperature.

2. Effects of alternative flow regimes on juvenile salmon habitat will be evaluated as part of the alternatives analysis report. This analysis will include discussion of habitat trade-offs associated with the alternative regime

3. The effects of the recommended flow regime on juvenile rearing habitats will be discussed in the final impact assessment which will also describe the method which was used to arrive at the recommended flows and the trade-offs made.

FIGURE 4-

Evaluation of Conditions For Clearing: Side Sloughs

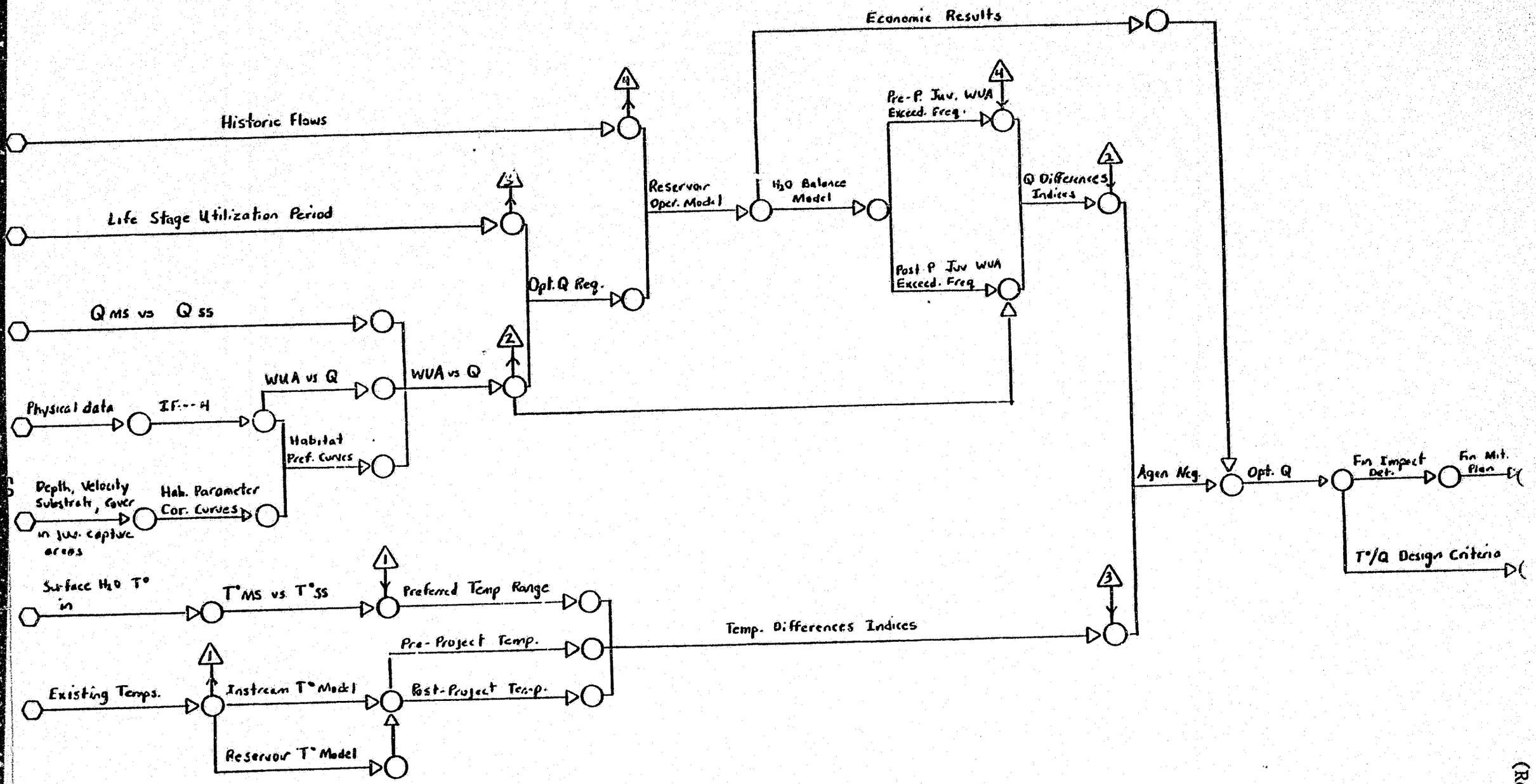


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FIGURE 4

Evaluation of Conditions For Spawning: Side Channels

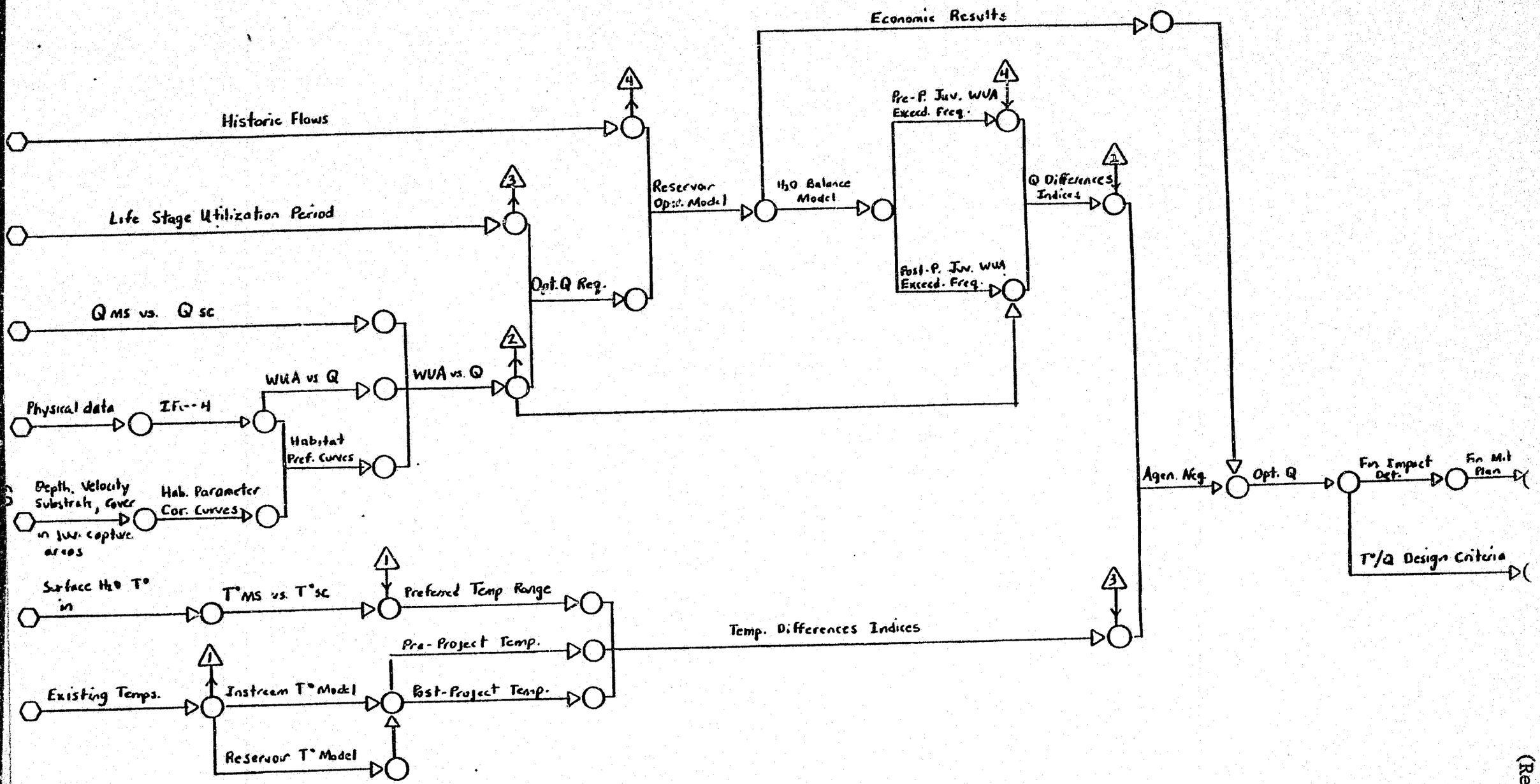

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FIGURE [redacted]C

Evaluation of Conditions For [redacted]rg : Tributary Mouths

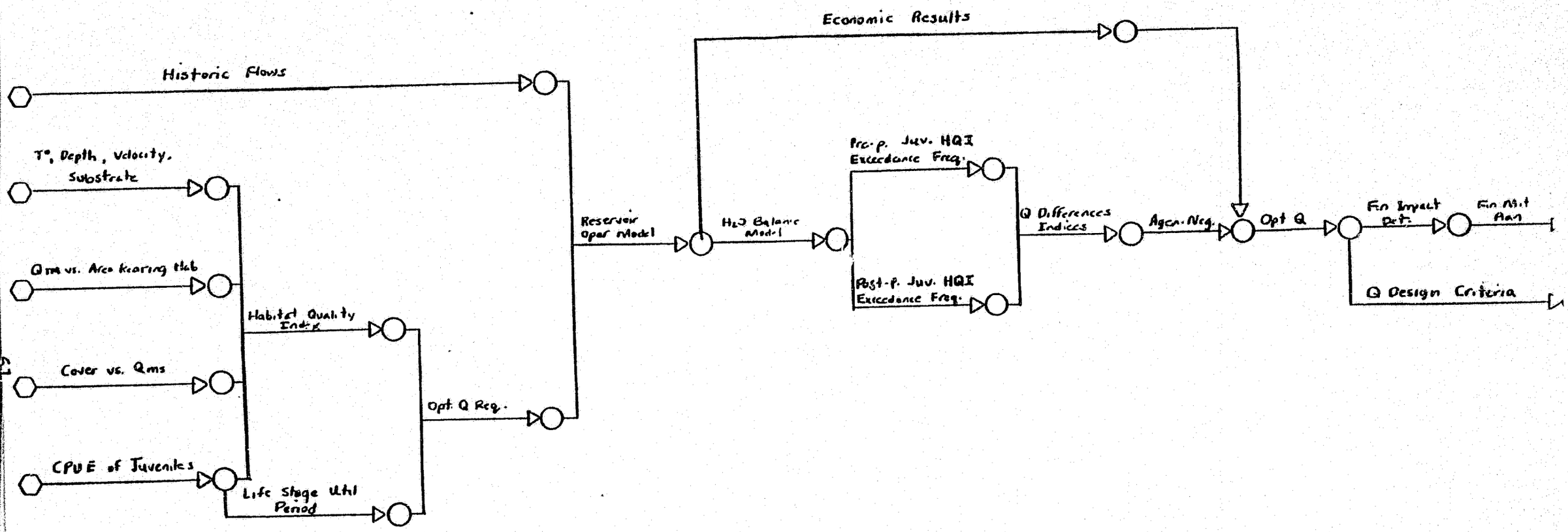


FIGURE 4D

Evaluation of Conditions For Rearing : Mainstem

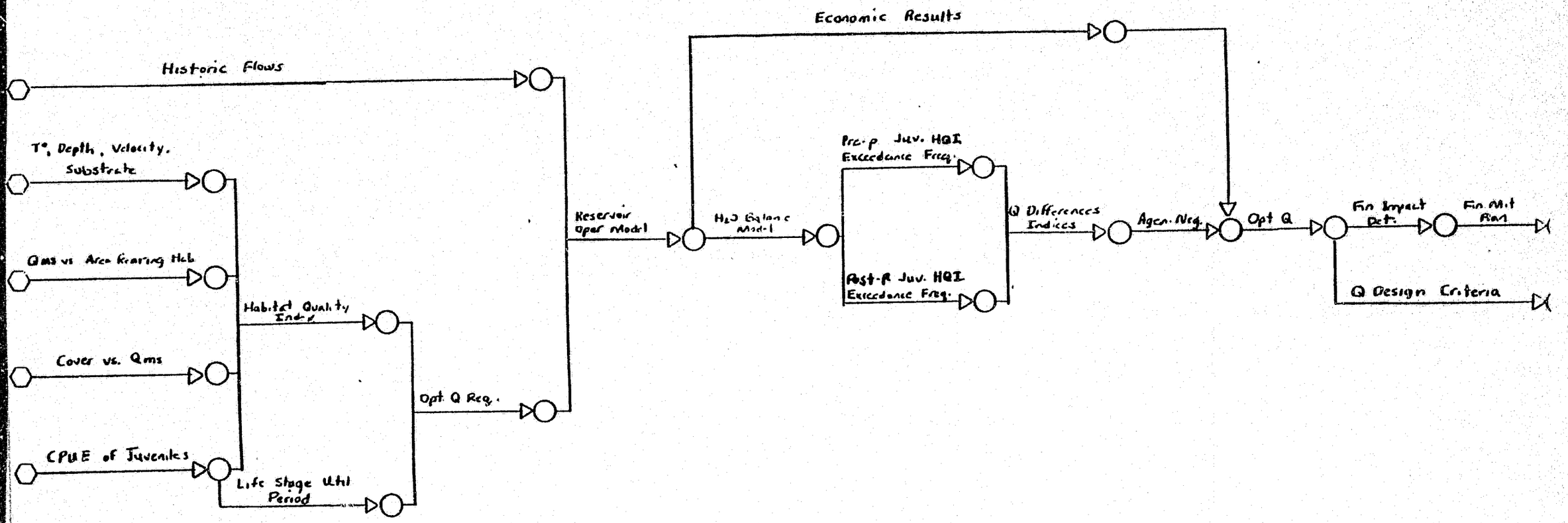
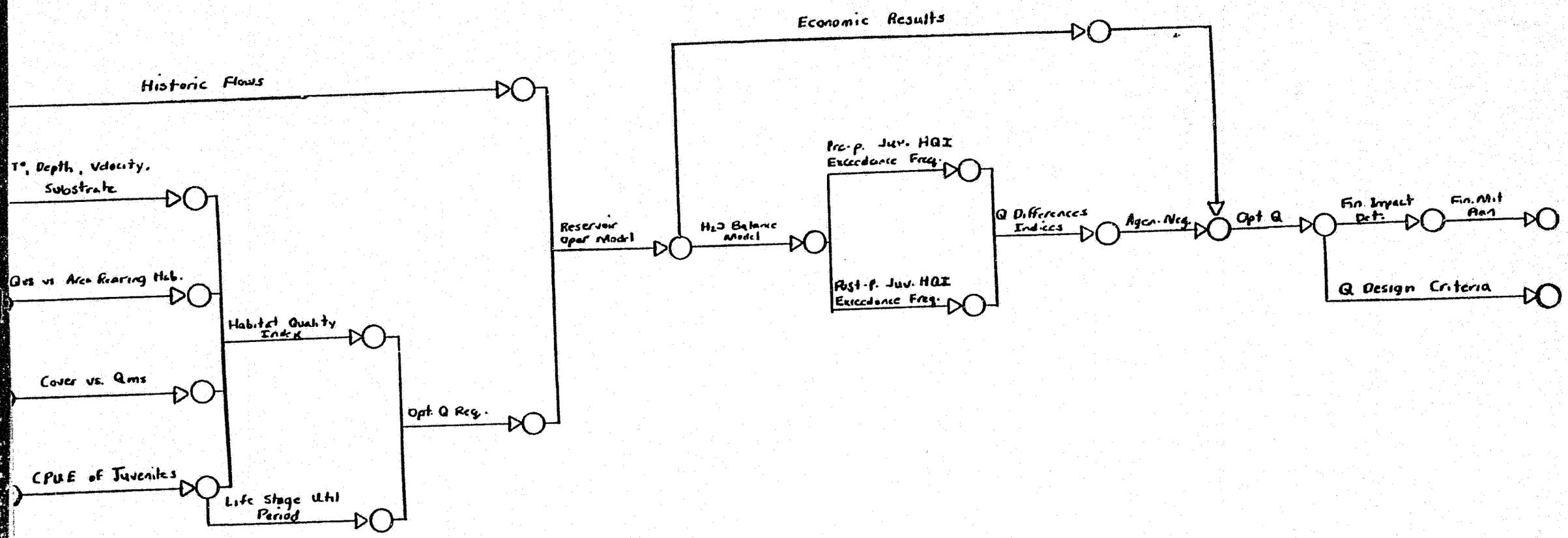


FIGURE 4-4E

Evaluation of Conditions For Rearing: Upland Sloughs



4.4.6 Coordination Among Study Participants and Other Activities

Responsibilites for data collection, analysis and evaluation will be as described for the tasks presented in Sections 4.1, 4.2, and 4.3.

4.4.7 Schedule and Deliveable

Deliveable	Due Date
1. Life Stage Utilization Period	Available
2. Mainstream Discharge vs Habitat Discharge	8/31/84
3. WUA vs. Mainstream Discharge	8/31/84
4. Habitat Quality Indices	8/31/84
5. Comparison of Alternative Flow Regimes	3/31/85
6. Recommended Flows	4/01/85
7. Final Impact Assessment	6/30/85

4.5 TASK 5 - EVALUATION OF CONDITIONS DURING OUTMIGRATION OF JUVENILE SALMON

4.5.1 Background

4.5.1.1 Rationale. Juvenile Pacific salmon outmigrate from the Susitna River throughout the open water season. The outmigration begins in a variety of lateral habitats, depending on the species, and is completed as the smolts move into the mainstem and subsequently to Cook Inlet.

The movement from lateral habitats into the mainstem occurs primarily during spring and early summer when flow is high. There is a concern that low with-project flows during this period may impact the ability of juveniles to outmigrate at the proper time. The time of outmigration is often keyed to environmental conditions in the rearing estuary and an alteration of outmigration timing could affect survival or growth rates of smolts in the marine environment.

4.5.1.2 Previous Studies. ADF&G conducted studies on the timing of smolt outmigation and, as discussed in Section 4.4, habitat use prior to outmigration (ADF&G 1983a).

In the Devil Canyon to Talkeetna Reach, pink salmon fry apparently outmigrate in association with break-up in late April and May. Movements are from the incubation areas, primarily tributaries and tributary mouths, into the mainstem. Chum salmon fry outmigrate in June, although some continue to outmigrate into early August. Movements are from the early rearing areas, primarily low velocity areas such as sloughs, side channels and tributary mouths, into the mainstem. Most sockeye outmigrate from the Devil Canyon to Talkeetna Reach as Age 1 fish in July, although some migration occurs throughout the open water season. Migration is usually from sloughs into the mainstem. Coho salmon outmigrate as age 2 smolts, primarily in May and early June, while chinook outmigrate as age 1 smolts in June and early July.

Coho smolts move from habitats influenced by tributaries, such as sloughs with tributaries, upland sloughs, and side channels with tributaries, while chinook smolts move from a variety of low-velocity habitats.

An analysis and discussion of relationships between physical conditions and outmigration timing in 1982 is presented in Appendix H of the Synopsis Report(ADF&G, 1983a). Significant correlations were found between outmigration and season, day length, discharge and temperature, depending on the species. The correlation coefficients, however, were generally low to moderate. It is possible that a significant portion of the outmigration occurred during break-up when ice conditions precluded sampling.

4.5.2 Questions to be Answered

To complete the analysis of salmon habitation in the Susitna River, one final question must be answered:

> Under what conditions do juvenile salmon outmigrate from the Susitna River to Cook Inlet and what are the stimuli to the outmigration.

In many respects this is a physiological question which cannot be completely answered by evaluating the environments in which the juvenile salmon are found. However, it is important to determine whether the physiological process is coupled to a set of environmental conditions which will be altered as a result of the proposed project. Some of the potential stimuli include:

1. Discharge
2. Temperature
3. Turbidity
4. Photoperiod or day length
5. Floods

Of these, the operation of the Susitna Project may alter all factors but photoperiod.

Results of the Task 3 incubation and Task 4 rearing studies will be useful in evaluating the questions pertaining to outmigration.

4.5.3 Study Locations

Studies of outmigrant salmon have been and will continue to be conducted at the following locations:

Sloughs:	8A, 9, 11, 21
Mainstem:	Talkeetna Fishwheel Site

4.5.4 Detailed Methodology

4.5.4.1 Data Requirements and Formats. Data needed to evaluate smolt outmigration include the timing of outmigration for each species, the habitats from which the migrants are moving and variation in physical parameters (including temperature, discharge, photoperiod and turbidity) during the outmigration.

4.5.4.2 Sampling and Analysis. Additional sampling to relate smolt out migration timing to physical variables is not warranted at this time.

Analysis consists of evaluating the relationships between physical variables and outmigration timing for each species and comparing the results to similar information obtained elsewhere. Once the conditions leading to outmigration have been identified, the impacts of changes caused by the project can be evaluated. The analytical framework for the evaluation of outmigration is presented in Figure 4-5 (A-D).

4.5.5 Report Formats

The report on outmigration will contain, for each species, information on:

1. Summary of literature dealing with outmigration timing;
2. Timing of outmigration in the Susitna upstream from Talkeetna during 1982 and 1983;
3. Evaluation of timing with respect to temperature, discharge, photo period and turbidity;
4. Discussion of conditions that lead to outmigration, based on 1982 and 1983 data; and,
5. Anticipated changes in these conditions under project operation

4.5.6 Coordination Among Participants and Other Activities

Items 1-4 in Section 4.5.5 will be performed by ADF&G. The anticipated impacts caused by project operation will be determined by AEIDC and reviewed by the project team.

4.5.7 Schedule and Deliveables

Deliveables	Due Date
1. Conditions Leading to Outmigration	6/30/84
2. Flow Relationships	8/31/84
3. Evaluation of Alternative Regimes	3/31/85
4. Recommended Flows	4/01/85
5. Final Impact Assessment	6/30/85

FIGURE 4-9A

Evaluation of Conditions for Outmigration : Side Sloughs

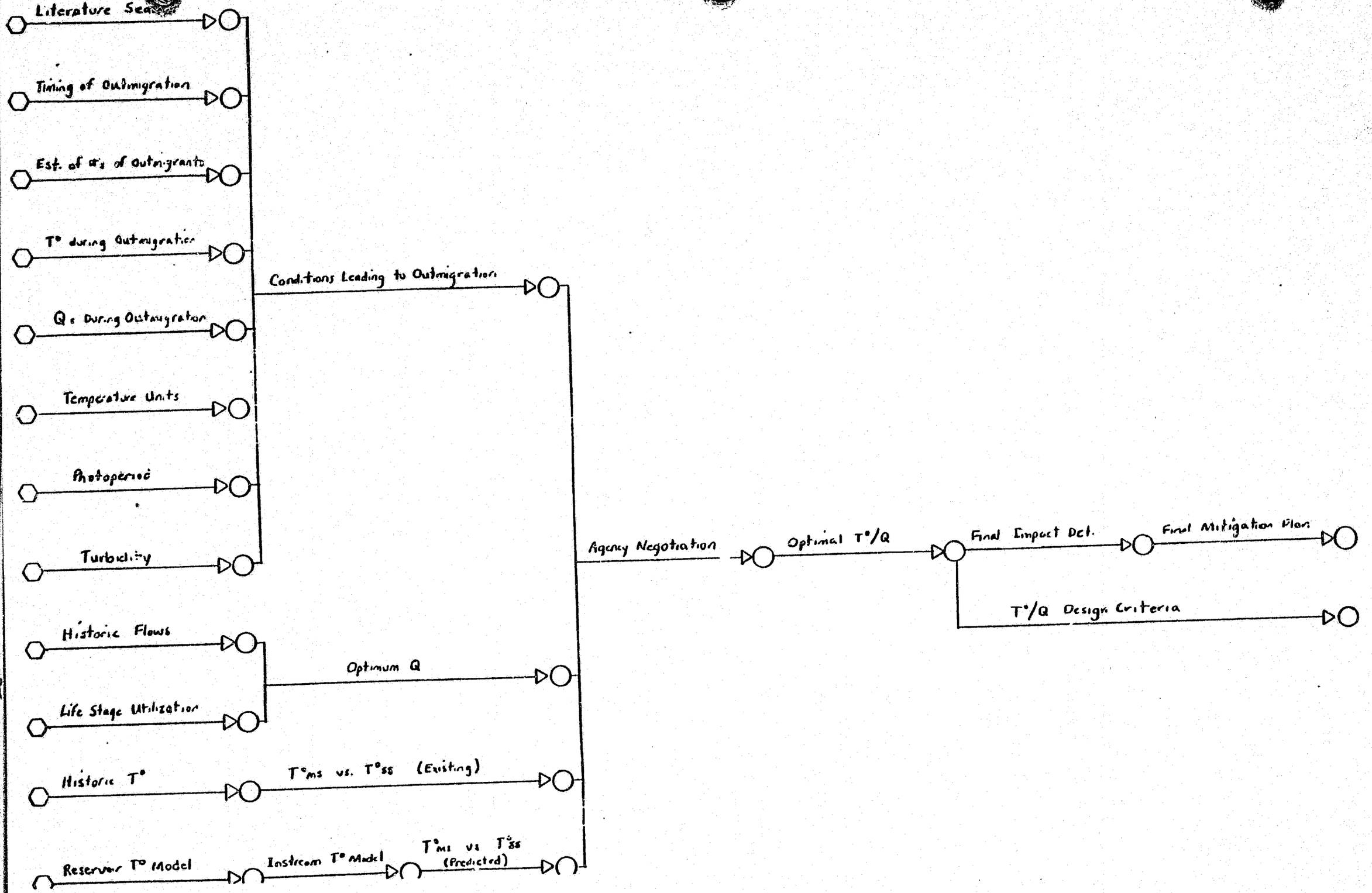


FIGURE 4-5B

Evaluation of Conditions for Outmigration : Side Channels

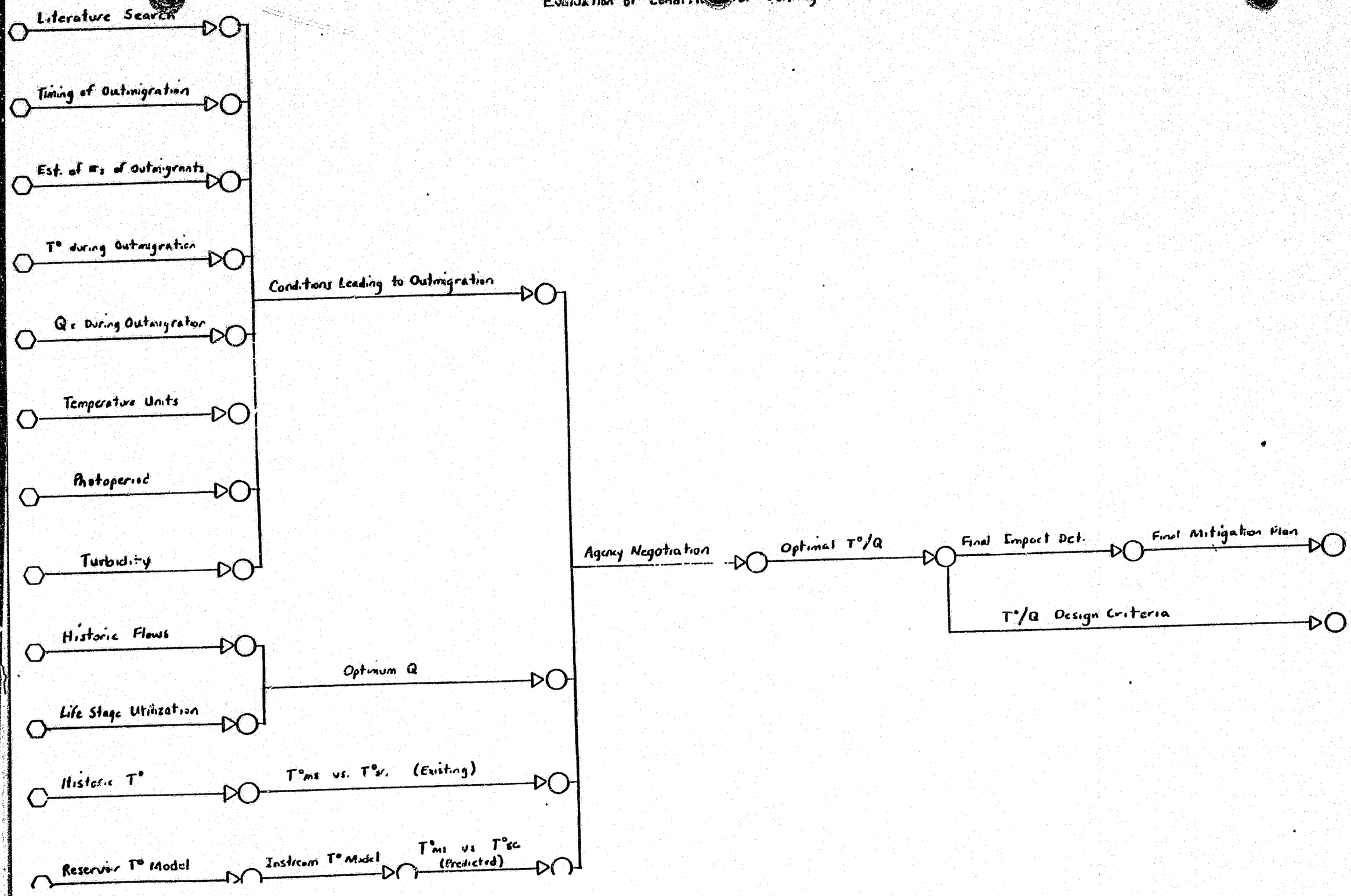


FIGURE 4-5C

Evaluation of Conditions for Outmigration : Tributary Mouths

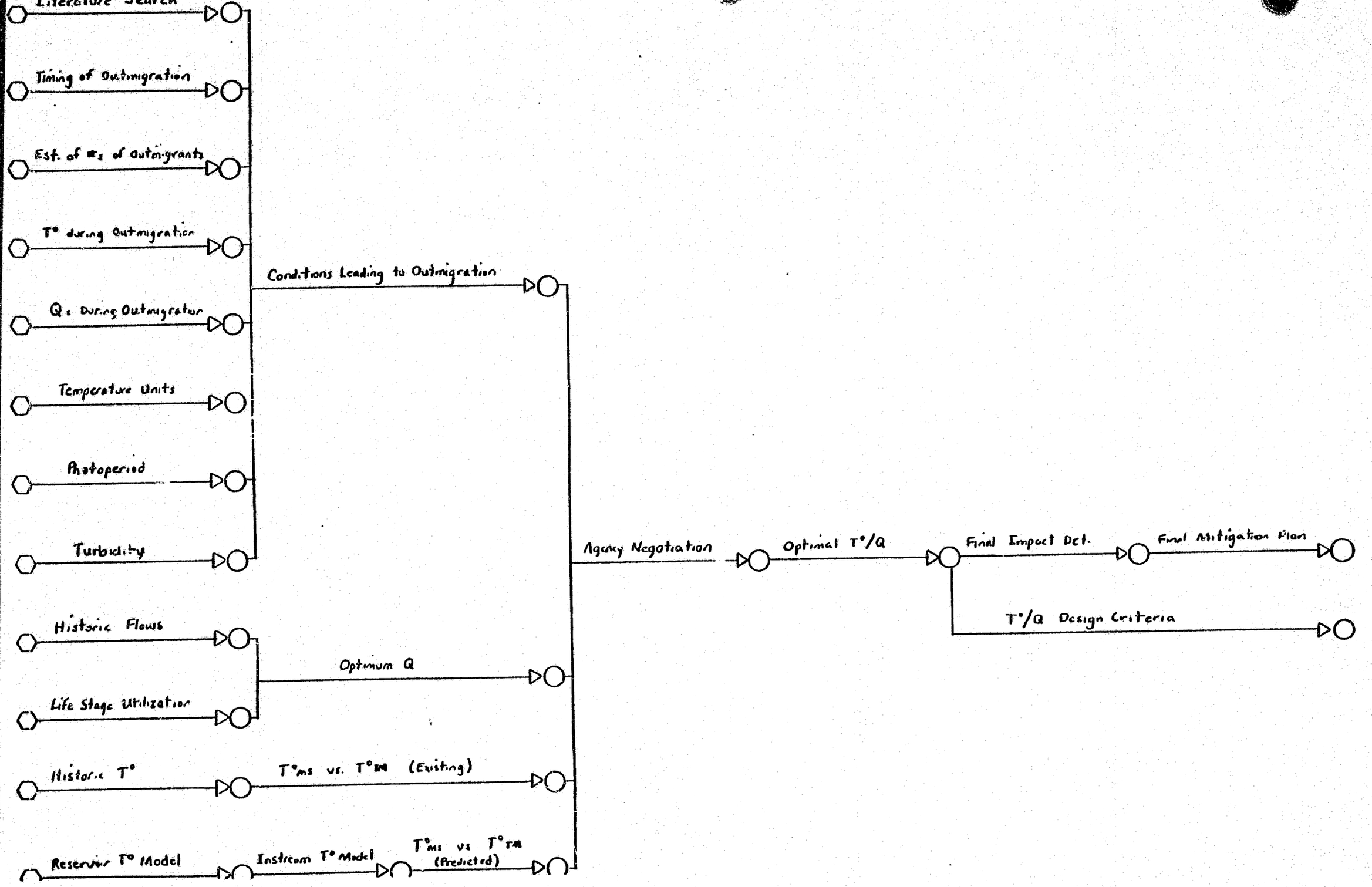
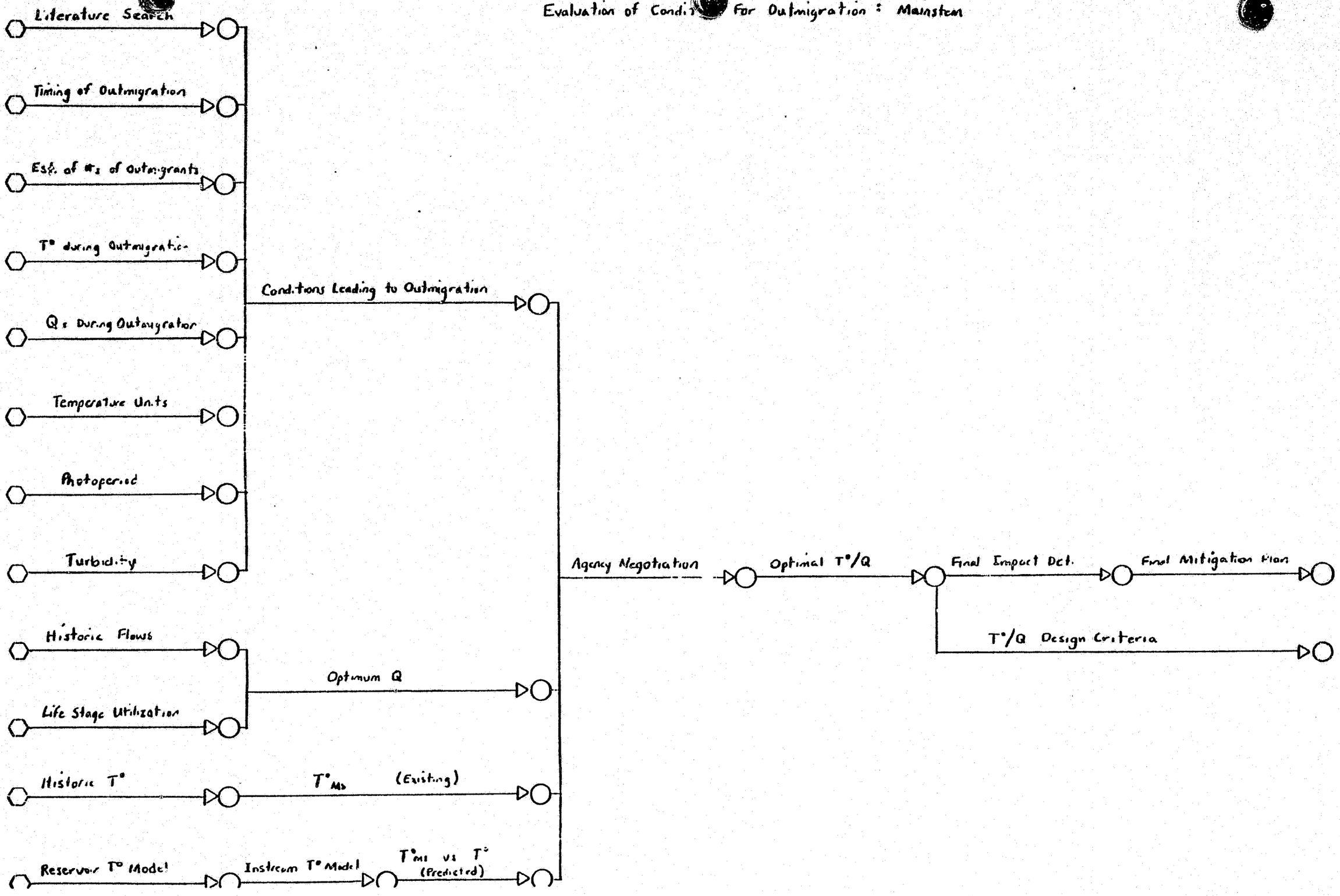


FIGURE 4-5D

Evaluation of Condi[illegible] For Outmigration : Mainstem



4.6 TASK 6 LOWER RIVER STUDIES

Studies of the river between Talkeetna and Cook Inlet will be expanded in 1984. Reconnaissance level studies have been completed and will be utilized to develop a study plan initiated during FY84 and continued FY85. This draft plan is summarized here.

4.6.1 Plan of Development for Lower River Study

Numerous questions have arisen concerning the effects of the Susitna Project on the reach of the Susitna River between Talkeetna and Cook Inlet. In FY84, preliminary studies have been initiated to develop a comprehensive plan to address the key questions focusing on this reach of river. The development and implementation of the Detailed Plan of Study will be through the steps outlined below.

4.6.1.1 Development of Plan of Study.

1. Analysis of the results of the Lower River Morphological Assessment Report by R&M.

   This consists primarily of an evaluation of how the morphology of the river changes with discharge. Although the data will be available to describe the entire river reach, special emphasis will focus on 8-10 specific areas including:

   a. Alexander Creek area
   b. Mouth of the Kashwitna River
   c. Mouth of Willow Creek
   d. Sunshine Creek and Slough

e. Birch Creek and Slough

f. Delta Islands area

2. Summarization of biological information available for the Lower River.

ADF&G has conducted analyses of various fish habitats in the Lower River over the past years for resource purposes. The information available will be summarized in our document and utilize in planning additional studies.

3. Draft Plan of Study

A Draft Plan of Study will be developed based upon results of the two previous tasks and through discussions with the ADF&G, resource agencies subcontractors and the Power Authority. Review of agency comments on the draft and final Exhibit E will assure that questions raised by the agencies can be addressed through the studies.

4. Stratification of Lower River Habitats (Report by R&M and AEIDC)

The stratification of the Lower River habitat types will enable selection of representative areas for detailed studies. It will involve classification of reaches of the river into specific groups from which representiative study areas may be selected.

5. Selection of Study Areas

Final selection of study areas for detailed study will be based on the results of the stratification. Once the selection of study areas is made, specific study plans and methods will be established so that data collected will be as quantitative as possible.

6. The Final Plan of Study will detail the specific study elements for each of the selected study areas. This will include approximate study location methods, and draft formats for presentation of results. The final study plan (after contractor selection) will also specify who will be responsible for each part of the study and how the study will be coordinated.

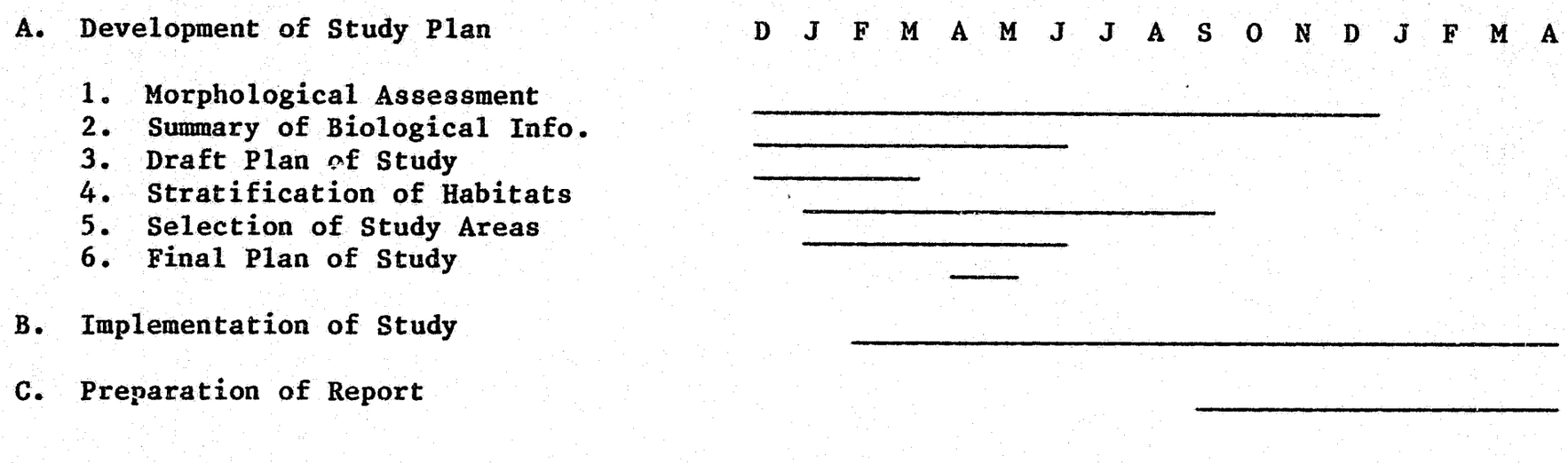
4.6.1.2 Implementation of Study. Implementation of the study will be according to the plan defined above. All field data will be collected during the 1984 field season. Preliminary analyses will be conducted to determine whether or not the data collected meet the needs for analysis. When necessary, modification to the plan will be made.

Preparation of the final report include the following elements:

1. Preparation of detailed report outline
2. Analyses of data
3. Preliminary draft of the report for internal review
4. Final draft report for external review and Power Authority review
5. Final report preparation for delivery to FERC

TABLE 4-1 LOWER RIVER STUDIES

SCHEDULE



4.7 TASK 7 - NAVIGATION/RECREATION

A study of the navigability of the Susitna River under with-project conditions is currently being planned. Although this study is not in our present FY84 workscope, a detailed plan of study for the 1984 field season will be developed by March 31, 1984.

5.0 QUALITY ASSURANCE PROGRAM

5.1 PURPOSE

The purpose of the Harza-Ebasco Quality Assurance (QA) Program is to provide a measure of control over the quality of the Susitna Hydroelectric Project environmental studies and some assurance that resulting data and reports represent quality end-products which will withstand public and professional scrutiny. The Environmental QA Program comprises all planned and systematic actions, including quality analysis and corrective actions, necessary to provide adequate confidence in the results of the Aquatic, Terrestrial and Social Science Programs. It will conform in all respects to the Harza-Ebasco Quality Control Plan.

5.2 GENERAL APPLICATON

This QA Program will be applied specifically to all Harza-Ebasco management activities and subcontractor technical activities related to the Susitna Hydroelectric Project environmental studies. Also, where these activities interface directly with other project tasks, such as hydrologic and hydraulic studies, elements of this QA Program may be applied. The Environmental QA Program addresses four major aspects: organization and responsibilities; operating procedures; document control; and audits. Specific QA guidelines and actions will be implemented with each subcontractor to assure quality, reliability, redundancy and traceability of technical data, information, and project records.

The QA Program for the environmental studies is compatible with the Harza-Ebasco Quality Control Plan as defined in Exhibit 7 of the Harza-Ebasco Susitna Hydroelectric Project contract with the Alaska Power Authority. In addition, this QA Program complies with the "Ebasco Quality Manual for Hydroelectric Power Stations" which has been identified as a guidance document for this Project. Finally, the QA Program for environmental studies is

in conformance with the General Investigation Memoranda for the Aquatic, Terrestrial and Social Sciences Program.

5.3 ENVIRONMENTAL STUDIES QA PROGRAM CONTENTS

All subcontractors will be required to incorporate and document quality assurance in their studies. This will include procedures for data collection, checking, and storage, analytical procedures, analyses performed on data, and processes for incorporating data into final reports.

Other items included in the QA Program will be organization charts, lines of authority and identification of the person(s) responsible for QA, methods for assuring competency and safety of files, audit programs and the identification of persons responsible for technical quality of the reports.

5.3.1 Organization and Responsibilities

The QA Program will address the organizational structure, functional responsibilities, levels of authority, and lines of internal and external communication for management, direction, and execution of the environmental studies. All key positions and their project relationships, one to another, will be clearly defined. These positions include, but are not limited to:

Power Authority	Harza-Ebasco	Subcontractors
Project Manager	Project Director	Project Managers
Deputy Project Managers	Project Manager	Technical Leaders
Technical Leaders	Operations Manager	
	Group Leaders	
	Principal Staff	

5.3.2 Operating Procedures

The QA Program will define efforts to oversee the quality of the Harza-Ebasco management responsibilities as well as the technical accuracy of the study products. In short, all operating procedures dealing with field or other data collection, laboratory or office analysis, and the reporting of results are of concern to the QA Program.

5.3.3 Document Control

Criteria for document and data identification, logging of incoming and outgoing documents, document review, approval and release, document checks, distribution, use, and revisions are addressed by the QA Program. This QA Program describes the system of control for all project documents which have an effect on quality-related environmental activities, and provides guidelines for the filing, collection, storage, disposition, and maintenance of records affecting the quality of the project including project data.

5.3.4 Audits

The QA Program provides for a variety of audit activities which may be applied to the Susitna Hydroelectric Project environmental studies. These activities may include internal inspection of Harza-Ebasco project files, external audits of subcontractor files against their QA Manual and procedures, and surveillance of subcontractor field and laboratroy data gathering and analysis activities to assure compliance with their QA Manual and procedures.

Internal inspections of Harza-Ebasco project files may be conducted by the Project Director, Project Manager or Operations Managers at any time during the project. External audits and surveillance activities of subcontractors will be performed by Operations Managers or Group Leaders at least once per year and possibly more often at the discretion of the Project Manager.

5.3.5 Harza-Ebasco QA

Harza-Ebasco will develop a generic QA Manual to encompass studies in which it directly participates and to include an overview of QA procedures by all environmental subconsultants. This QA Manual will be compatible with other project requirements and will serve as the umbrella over the Susitna Hydroelectric Project environmental studies. The contents of the Harza-Ebasco QA Manual will include at a minimum:

- Copies of the subcontractor's procedures and QA Manual.
- QA responsibilities including levels of authority.
- Safety, location, duplication of data files.
- Applicable audit programs.
- Procedures for maintenance of QA records.
- Technical review procedures.

5.4 QA PROGRAM APPLICATION TO THE AQUATIC PROGRAM

The QA Program of the Aquatic Program will comform to the general guidelines outlined previously. A discussion of the Organization and Responsibilities, Operating Procedures, Document Control and Audits follows. Each of these aspects will follow the guidelines set forth in the Harza-Ebasco generic QA Manual.

5.4.1 Organization and Responsibilities

Within the Harza-Ebasco Organization, the Aquatic Studies Program is operated under the Environmental Operations Manager who is responsible for the management of the Environmental Study Team. The Operations Manager is assisted by the Aquatic Program Group Leader. The Aquatic Program Group Leader is responsible for management of the Aquatic Program Study Team and is responsible for the overall technical quality of the output from the program.

Assisting the group leader are staff persons who have the following responsibilities:

Fisheries Biologists: Responsible for the technical quality of the biologcial components of the Aquatic Study Program.

Aquatic Ecologists: Responsible for the water quality studies and the interelationship of aquatic organisms in the river system.

Hydrologist: Responsible for liaison with the Hydrologic and Hydraulic Study Team and interpretation of physical characteristics of the riverine system.

The Aquatic Program staff is supported by four subcontractors and the Alaska Department of Fish and Game Susitna Hydroelectric Aquatic Study Team. The responsibilities of these organizations are described in Section 1.2.

5.4.2 Operating Procedures

The Aquatic Program Operating Procedures for the QA Program includes a full range of technical review of data collection, data analysis and reporting of results. Periodically, the Aquatic Program Staff will conduct site visits with persons responsible for data collection to ensure data collection methods are in conformance with the technical requirements for the collection and analysis. These site visits will usually be pre-arranged with the appropriate persons, however unanounced spot checks may be conducted.

Review of technical documents will be conducted to ensure the technical quality of the reports. The review procedure will be as follows:

In House Reports

Internal Review: Draft reports will first be reviewed by the Aquatic Program staff to ensure that the reports are in conformance with contractual obligations and are technically sound.

External Review: Once the reports have been reviewed and revised internally, drafts of the report will be reviewed by members of the Aquatic Study Team; this includes all subcontractors.

Final Review: The final draft will be reviewed by the Power Authority for compliance with general policies set forth for the Susitna Project.

Subcontractor Reports:

Internal Review: Each subcontractor will review their own reports internally to assure technical quality.

External Review: Each of the reports will then be reviewed by Harza-Ebasco and members of the Aquatic Study Team.

Final Review: The final draft will then be reviewed by the Power Authority for compliance with its standards.

Completion of the review process will result in a final report which will be transmitted to the Power Authority for approval before distributing to the appropriate organizations.

5.4.3 Document Control

The Document Control program for the Aquatic Group is subsumed under the general guidelines set forth for Harza-Ebasco Document Control.

5.4.4 Audits

Each subcontractor is responsible for developing QA procedures for their operations. These QA procedures are prepared either as a separate QA manual or are contained with in the contract scope of work. At least one audits per fiscal year be made of the QA procedures used by each of the subcontractors.

6.0 ATTACHMENTS

6.1 References Cited in Plan of Study

Acres American, Inc. 1983. Application for license for major project, Susitna Hydroelectric Project, before the Federal Energy Regulatory Commission. Exhibit E, Chapter 3 Volume 6B. Alaska Power Authority, Anchorage, Alaska.

Alaska Department of Fish and Game. 1983a. Susitna Hydroelectric Project Aquatic Studies 1982 Phase II. Synopsis of the 1982 Aquatic Studies and Analysis of Fish and Habitat Relationships. Prepared for Alaska Power authority, Anchorage, Alaska.

_____. 1983b. Susitna Hydroelectric Aquatic Studies, 1982 Phase II Basic Data Report. Volume 4, Aquatic Habitat and Instream Flow Studies. prepared for the Alaska Power Authority, Anchorage, Alaska.

_____. 1983c. Susitna Hydroelectric Aquatic Studies, 1982 Phase II Winter Data Report (October 1982-May 1983). Prepared for the Alaska Power Authority, Anchorage, Alaska.

_____. 1983d. Susitna Hydroelectric Aquatic Studies, 1982 Phase II Basic Data Report Volume 3. Resident and Juvenile Anadromous Fish Studies on the Susitna River below Devil Canyon. Prepared for Alaska Power Authority, Anchorage, Alaska.

R&M Consultants, Inc. 1982. Tributary Stability Analysis. Prepared for the Alaska Power Authority, Anchorage, Alaska.

Trihey, E.W. 1982. Preliminary Assessment of access by Spawning Salmon to Side Sloughs Habitat above Talkeetna. Prepared for Acres American, Inc. Anchorage, Alaska.

_____. 1983. Preliminary Assessment of access by Spawning Salmon into Portage Creek and Indian River. Prepared for Alaska Power Authority, Anchorage, Alaska.

Wangaard, D. and C. Burger. 1983. Effects of Various Temperature Regimes on the Incubation of Susitna River Chum and Sockeye Salmon. National Fishery Research Center, U.S. Fish and Wildlife Service, Anchorage, Alaska. Prepare for Alaska Power Authority, Anchorage, Alaska.

6.2 General Schedule for Aquatic Studies Program, FY84 and FY85

The attached figure 6.1 provides the preliminary schedule for the Aquatic Studies Program through fiscal year 1987.

Figure 6.1

SUSITNA HYDROELECTRIC PROJECT

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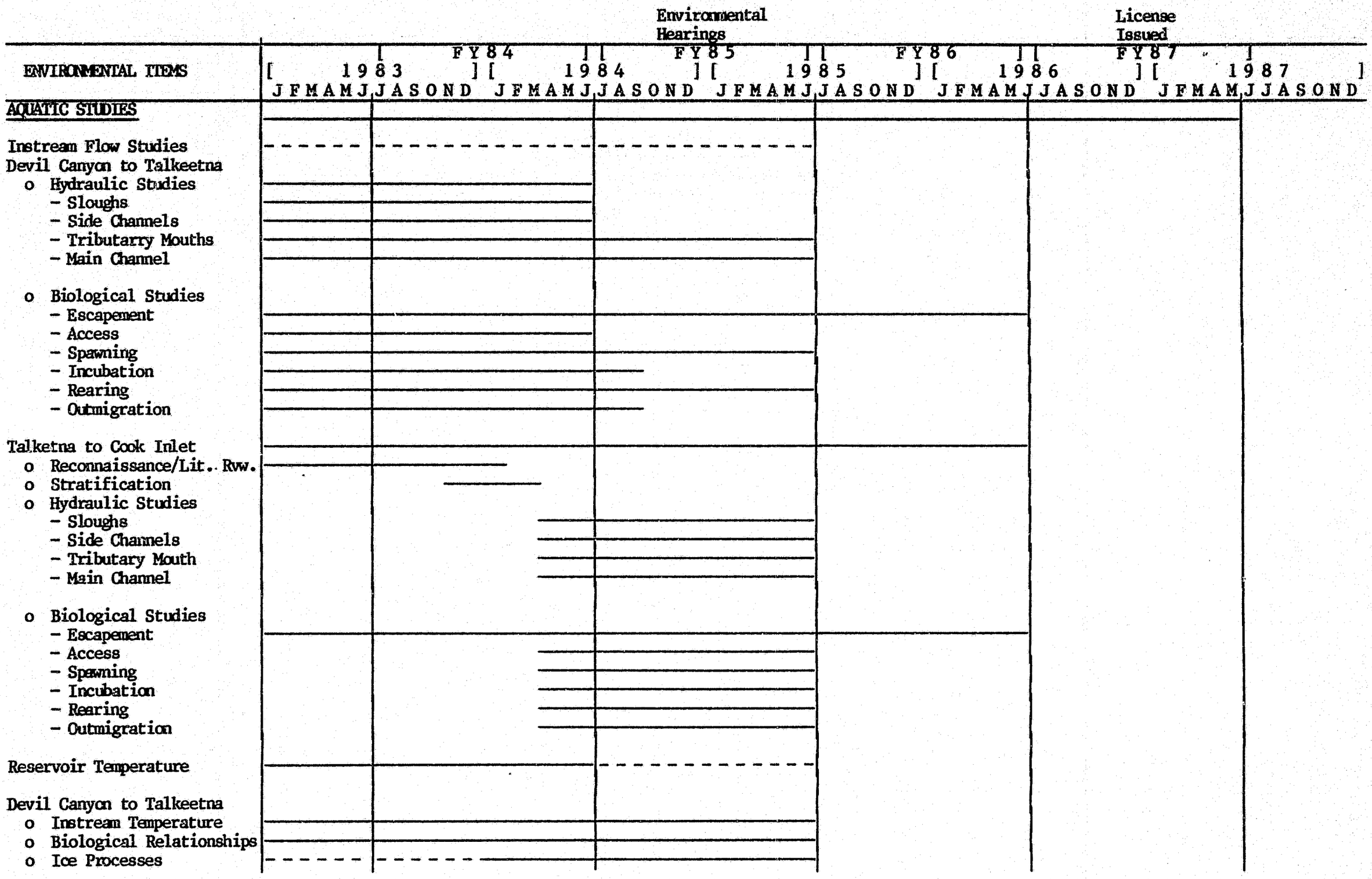

Figure 6.1

SUSITNA HYDROELECTRIC PROJECT

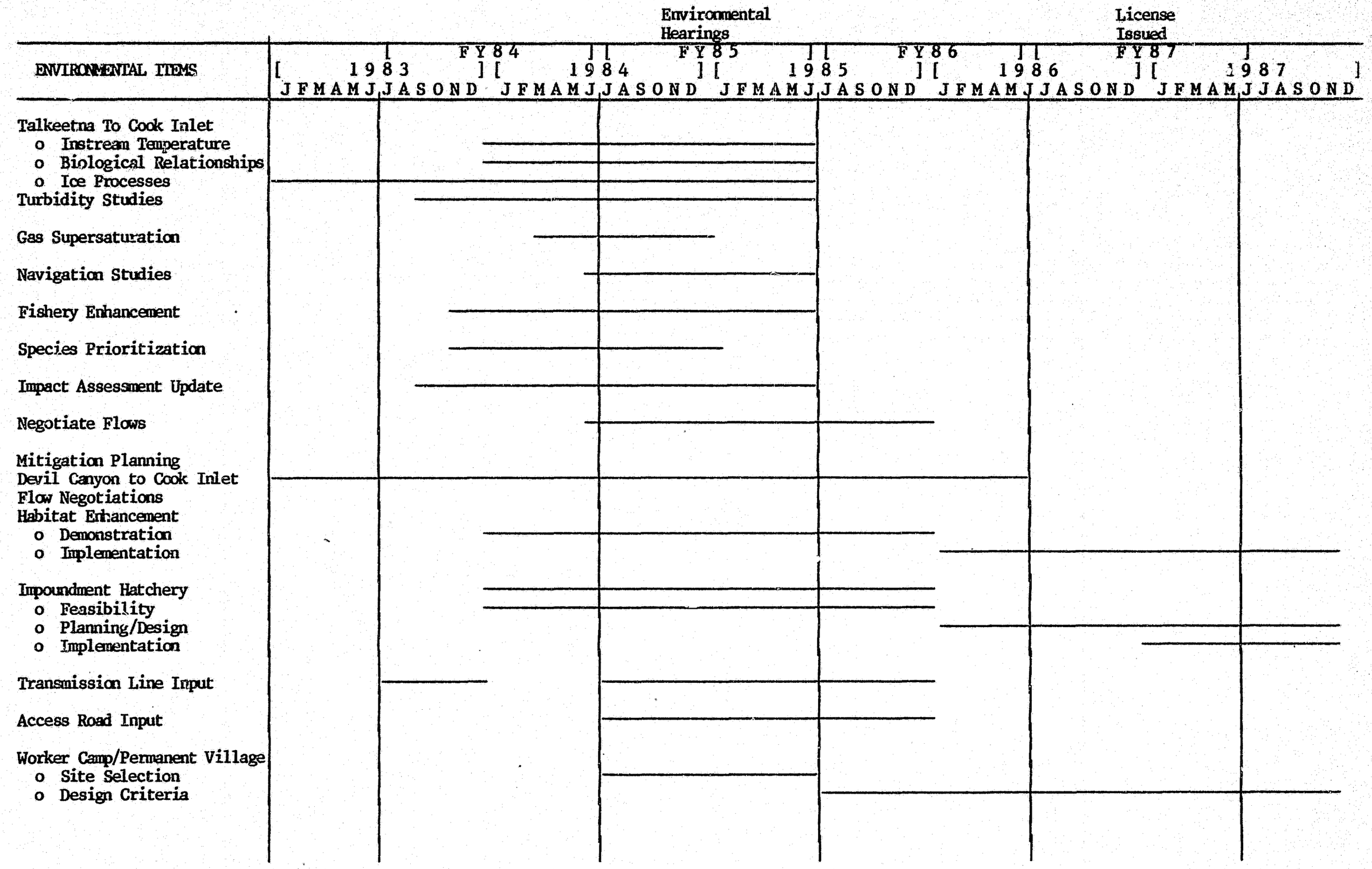

Figure 6.1

SUSITNA HYDROELECTRIC PROJECT

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