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Examination of Tidal Flats Vol. 3 - Evaluation Methodology

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Examination of Tidal Flats
Vol. 3. Evaluation Methodology

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U.S. Department
of Transportation

**Federal Highway
Administration**

FOREWORD

This report is one of three volumes on tidal flat values. The first volume summarizes the data collected on the biological communities and processes in tidal flats, and recommends that evaluation guidelines consider habitat (grass bed, sand or mud), season, and geographic location. Volume two is a state-of-the-art report which discusses tidal flat values as documented in the literature. Volume three is a methodology for evaluating tidal flats and established a basis for comparing sites.

These reports will be of value to anyone concerned with the values associated with tidal flats in general and with the possible impact of highways on these systems. It is especially appropriate for environmental specialists, biologists, and hydrologists and engineers concerned with highway location and design.

for Charles F. Scheffey
Director, Office of Research

NOTICE

Technical Report Documentation Page

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16. Abstract

This report is the third volume of three, documenting a study titled "Evaluation of Tidal Flat Areas for Highway Planning and Design." The companion volumes to this report are the research report, "Examination of Tidal Flat Areas: Vol. 1, Research Report" and "Examination of Tidal Flat Areas: Vol. 2, A Review of Identified Values."

This report describes an approach to the evaluation of tidal flats which centers around state-of-the-art knowledge for: 1) assessing the values of tidal flats and 2) establishing the basis for comparison of specific sites. Actual field data collected from various tidal flat areas around the U.S. and the world form the quantitative base for establishing value. While all areas have not been studied sufficient data exist to establish a range of value for a given parameter for a given tidal flat.

Parameters identified as important for evaluation of tidal flat value fall into two categories; 1) Primary producers (chlorophyll a concentration and light intensity) and 2) Support populations (annelid, mollusc, and crustacean biomass and abundance). These parameters while not obviously visible on the tidal flats do reflect the ability of tidal flats to support fishery and wildlife populations.

The structure of the methodology revolves around scaled value indices for all parameters considered. Guidelines for application and interpretation of the methodology are included.

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INTRODUCTION

The need to develop and implement techniques for environmental analysis of the effects of construction projects is recognized in the National Environmental Policy Act of 1969. While methodologies to meet this need have proliferated in the past several years, most have gone unrecognized or underutilized. To meet the particular needs of the State Highway Agencies for evaluating construction projects affecting tidal flat habitats, we have examined many evaluation approaches and developed a composite methodology that will best fit highway agency needs.

The intent of this manual is to explain the methodology developed for evaluating tidal flat habitats and its application in assessing project effects. A separate literature review (Diaz, et al., 1981a) of tidal flat values identified the properties and natural resources of greatest importance on tidal flats for consideration in the evaluation methodology. The main criteria in development of the evaluation methodology were:

- That it be based on quantitative data.
- Accuracy in portraying the value of all tidal flat areas.
- Replicability such that different evaluators of the same area get equivalent results.
- Adaptable to amount of time and funds available.
- Understandable and applicable by environmental professionals of different backgrounds.
- Have site specific application.

Factors and parameters included in the evaluation methodology are:

- Engineering data on type of project and expected physical effects.
- Descriptive physical data on various habitats within the project area.
- Primary producers.
- Support populations.

It is very important to keep in mind that regardless of the needs of a user the methodology is designed only to provide a relative measurement of a particular habitat's value. Management decisions are not part of the methodology but are made after its application. There are several ways envisioned for applying the results of the evaluation methodology, which will meet the needs of a variety of users:

- Base line survey for existing ecological conditions.
- Bases for projecting project effects on short and long term.
- Bases for determining mitigation effort.
- Bases for comparing relative habitat value of several project sites.

For the methodology to be most effective it is necessary to have specific objectives and defined management goals. The logical steps for application of the evaluation methodology then become:

- Define study area.
- State project objectives (e.g. transportation facility).
- Develop management strategy (e.g. routing, mitigation).
- Evaluate results considering project effects and management goals.

Before applying the methodology it is advisable to go over the entire manual to become familiar with the concepts and types of data used. The manual is organized into three basic parts:

- Conceptual base and structure of methodology.
- Data matrices for the evaluation parameters.
- Application of the methodology and evaluating results.

PART I: CONCEPTUAL BASE AND STRUCTURE OF METHODOLOGY

Approach

Our approach to developing the evaluation methodology has been to rely upon state-of-the-art knowledge for: 1) assessing the values of non-vegetated tidal flat wetlands and 2) establishing the basis for comparison of specific sites. Actual field data collected from various tidal flat areas around the U.S. and the world form the quantitative base for establishing value. Sufficient data exist to establish a range of value for a given parameter for a given tidal flat. Data tables for various areas can be found in Volume 1 Research Report (Diaz, et al., 1981b). For any parameter of interest (e.g. primary productivity), there is a range for that parameter in a given tidal flat habitat. Even though data may not exist from a particular tidal flat it should fall within the range of all similar tidal flat habitats that have data for that particular parameter. In cases where data are nonexistent or too scarce to give a range of values, predictions based on data from the most similar habitats. This relieves the evaluator from having to quantify habitat value in areas where background data are scarce. All possible combinations of evaluation parameters and value index are covered.

This data base then forms the foundation of the methodology. By collecting data from a particular tidal flat of interest, comparison can be made to other similar habitat types. The range of a given parameter has been scaled for ease of interpretation, thereby reducing as much as possible the need for the user to be familiar with all aspects of tidal flat ecology. A value index is then derived from combinations of appropriate parameters based on the original data from tidal flats. The value index is scaled on the range of parameters from 0 to 3, with 0 being no value and 3 highest value. A four unit scaling of no, low, medium, and high value was felt to be the best for habitat evaluation considering the detail of data the value index was based upon. Any finer scaling, say from 0 to 10, would only give the appearance of being more precise and accurate. Current state-of-the-art data are not sufficiently detailed to support greater precision.

Selection of Parameters

Unfortunately the level of understanding of the relative values of different tidal nonvegetated wetland habitats, and therefore the parameters which can best be used in their evaluation, falls short of that for other wetland types (e.g. marshes). This is due in part to the lack of obvious and readily identifiable physical structure or life on tidal flats at low tide. The primary values of these habitats are then not obviously visible (e.g. trophic support of fisheries) and must be evaluated from parameters always present on the flats. While there is no doubt that nonvegetated tidal wetlands are among the most valuable of our coastal environments in support of fisheries resources, it is very difficult to directly measure fisheries or waterfowl populations. These populations are very motile often relying only on tidal flats for part of their life cycle, so that quantification of their presence on tidal flats would require a very intense field sampling program.

Parameters that are relied upon to evaluate the relative value of a habitat should then reflect the value of that habitat to fisheries and waterfowl species of management concern. The parameters should also be measurable whether the management species are present or not at the time of evaluation. Since trophic support of fish and waterfowl is the primary value of tidal nonvegetated wetlands, we have chosen measures of primary productivity and standing stock of invertebrate populations as the parameters on which to base habitat value.

Overall evaluation scheme

The structure of the methodology revolves around the scaled value indices for all the parameters considered and the time available to complete an evaluation. The flow chart of the methodology shows how it fits into the overall evaluation scheme for highway planning to facilitate routing decisions (Figure 1). Before attempting an evaluation it is necessary to become familiar with tidal flat values. Users are encouraged to examine Volume 1 and 2 in this series on examination of tidal flats (VIMS 1980a, 1980b).

The primary input to the methodology consists of:

- Specific Project Guideline - engineering data on the type of project, size of project, type of impacts, area of expected impact, expected magnitude of impacted, time duration of construction activities, life of project, projected secondary project impacts.

- Site characterization - the number of different tidal flat habitats present in the project area, areal extent of each habitat type, physical data from habitats.

These two inputs combine to form the stage from which the evaluation of project effects proceed. Detailed user worksheets explaining these inputs are in Appendix A.

Endangered Species Considerations

While there are no endangered species that are obligatory users of intertidal nonvegetated wetlands, there may be several that at one time or another would be observed near or on the flats. The occurrence of endangered species at an evaluation site is of concern and needs special handling as shown in figure 1. Water-oriented species comprise most of the recognized endangered birds. Dependence of these species on tidal flats directly is limited. The following list of federally recognized,

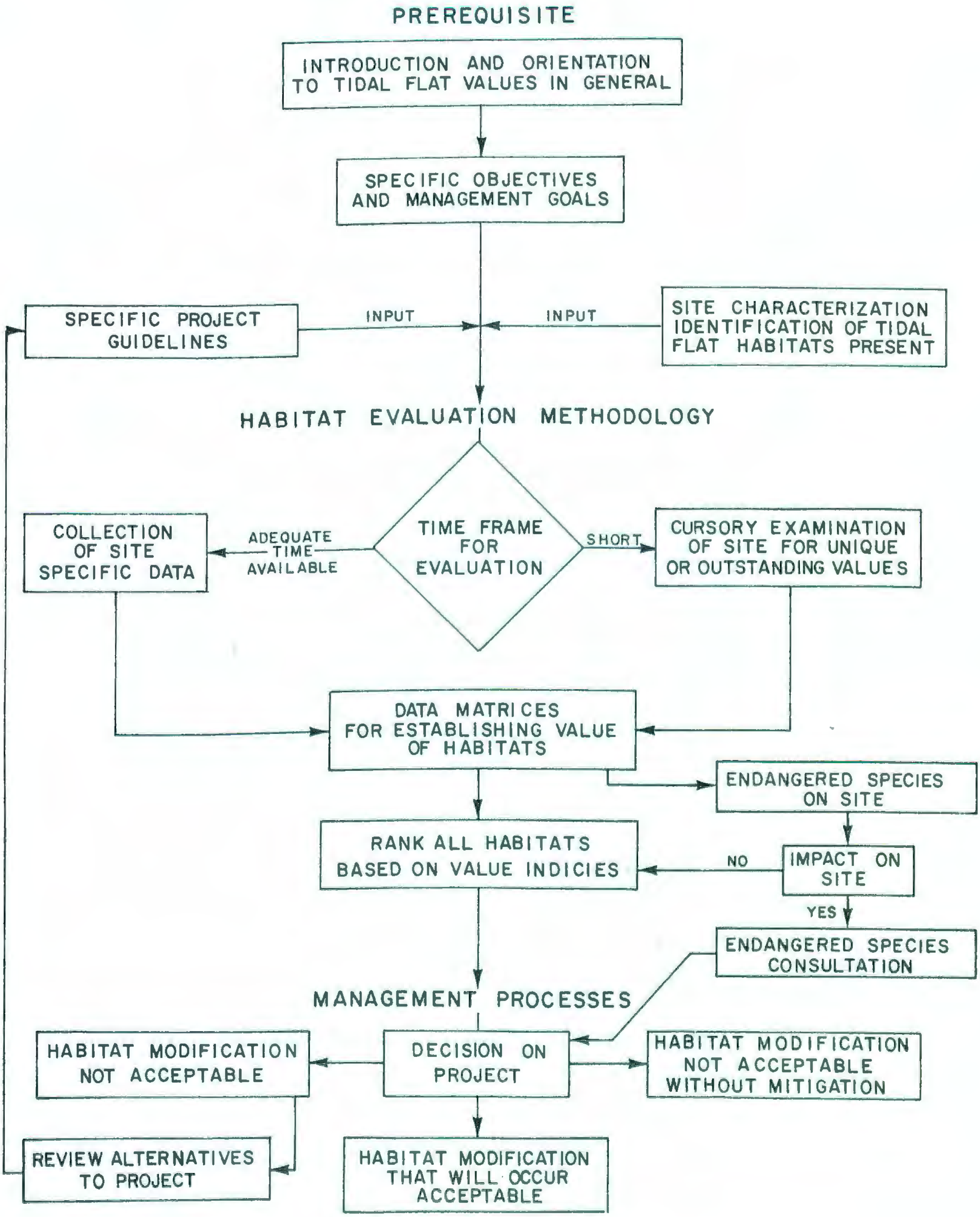

Figure 1. Flow chart of how the evaluation methodology fits into the overall scheme of environmental highway planning.

may not include species from state lists, endangered species may be associated with nonvegetated tidal flats;

Endangered Birds Associated With Tidal Flats

Southern Bald Eagle	(*Haliaetus leucocephalus*)
Peregrine Falcon	(*Falco peregrinus*)
Eastern Brown Pelican	(*Pelecanus occidentalis*)
Aleutian Canada Goose	(*Branta canadensis leucopareia*)
Light footed Clapper Rail	(*Rallus longirostris levipes*)
California Clapper Rail	(*Rallus longirostris obsoletus*)
Yuma Clapper Rail	(*Rallus longirostris yumanensis*)
California Least Tern	(*Sterna albifrons browni*)
Whooping Crane	(*Grus americana*)
Mississippi Sandhill Crane	(*Grus canadensis pulla*)

Time frame

With project guidelines and site character well understood the user proceeds to the time frame for the evaluation and the manpower resources that are available to conduct the evaluation:

° If time and resources are short only a cursory examination of the site is possible, with possibly only collection of a partial data set. In which case it is of the utmost importance to focus on the most critical aspects of predicted impact and habitat types that have been given the greatest management concern.

° If time is short but resources are not limiting then at least one complete set of data can be collected from the project site. Special care must be taken when interpreting data collected at one point in time. Animal communities are variable in time which correlates to temperature and their life history stages. The absence of a motile species at one time in the year does not necessary mean the habitat has no value for that species. You may have sampled at a time in the year when the species was not using the habitat.

° If time is adequate for a complete evaluation of a site but resources are limiting it may be possible to collect one complete data set during the most productive time of the year, usually spring and fall in temperate and subtropical areas or summer in boreal areas, or several partial data sets spaced over time. The management plan will help in deciding what to do. Usually samples through time will give the best overall view of habitat value.

° If time and resources are adequate to evaluate a site then the optimal habitat evaluation can be made. Complete data sets can be collected through time.

Application

Once collected and processed (Methods are described in Appendix B) the data are transformed into a value index by comparing your site data to the state-of-the-art data for similar habitats (See Part II for development of value index). The series of value indices for each parameter are then ranked by habitat, (work sheets are described in Appendix C) and depending upon what the objectives and goals of the evaluation were form the bases for:

- ° comparing habitats within a project site for baseline conditions.
- ° comparing alternate project sites.
- ° projecting whether habitat modifications from a project are acceptable.
- ° mitigation effort.

In summary, the theory and bases for our habitat evaluation methodology are simple and straightforward. The value of any habitat is best assessed against real data that have been collected from similar habitats. After you survey your own specific site or sites the methodology provides a rule to measure your site against and assign a relative ranking to several sites.

PART II: DATA MATRICES FOR THE EVALUATION PARAMETERS

Parameters

The data necessary to apply the habitat evaluation methodology are of two types;

1) Engineering and descriptive physical data on the project and various habitats within the project area,

2) Environmental data on the biological resources for application of the value index.

Procedures for recording the engineering and descriptive data are described in Appendix A. Appendix B describes methods for collection of environmental data. In this part of the methodology, we will detail how the environmental data are converted to the value index which forms the bases of the habitat evaluation methodology.

The environmental data are divided into two categories with the following measurements;

Primary producers
- Chlorophyll a concentration as mg/m^2
- Light intensity as $\mu E/m^2/sec$

Support Populations
- Annelid* abundance as ind/m^2
- Annelid biomass as g wet wt/m^2
- Mollusc* abundance as ind/m^2
- Mollusc biomass as g wet wt/m^2
- Crustacean* abundance as ind/m^2
- Crustacean biomass as g wet wt/m^2

Primary Producers

From the literature review and research report (VIMS 1980a, 1980b) it was found that primary production on tidal flats around the country could be characterized by measuring chlorophyll a and light intensity. This is in lieu of measuring production rates which are methodologically complex.

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* Annelids include polychaete and aquatic earthworms
Molluscs include clams and snails
Crustaceans include crabs, shrimp, crayfish, etc.

Methods for obtaining field data are in Appendix B. These two parameters can be converted to the value index by entering Figure 2. For example, if chlorophyll a concentration was 110 mg/m^2 and light intensity was 300 $\mu E/m^2/sec$ the value index for primary producers would be 2. This value index would then be recorded on the habitat evaluation Form FD (Appendix C). In the case of a tie, between value indices, it may be necessary to collect additional field samples unless the evaluator can make a tie breaking judgment based on other habitat characters.

Support Populations

For ease of application to a generalized habitat evaluation the numerous species that make up the support populations of important fisheries and waterfowl species have been placed into three phylogenetic groups. This is necessary because finer grouping would increase evaluation time with increased time spent on taxonomy. Also, there are insufficient data on individual species for habitat evaluation. From the literature survey and research report there appeared a need to consider region of the country, seasonality, and salinity in developing the value index for support populations. However the state-of-the-art data are too scanty to develop a separate value index figure for each combination of season, region, and salinity. We have combined all the data and produced one set of value index figures for the entire country taking into account salinity (Figure 3). While all three phylogenetic groups are important in trophically supporting fisheries, several mollusc and crustaceans also have significant commercial importance. This is reflected in the value index matrices, particularly in polyhaline salinities, with the shift to the left of the value index when large individuals are present.

Regionality is difficult to handle. Not only do the species that compose the support populations change from one region to the next, climatic differences can change growth pattern of the same wide ranging species. The value indices for support populations are based mainly upon data derived from temperate and subtropical regions (Figure 4). While biomass and abundance data are relatively scarce for the other regions, there seems to be some crude trends between regions (Diaz, et al. 1981a) as summarized below:

Region	Abundance	Biomass
Temperate and Subtropical	Reference Point	
Boreal	higher	higher
West Coast	lower	higher
Tropical	lower	lower

It must be kept in mind that these are generalities and that the range of variability of abundance and biomass overlap greatly between regions. When conducting an evaluation in a region other than temperate or subtropical and the value index for annelids, molluscs, or crustaceans is borderline it would be appropriate to apply a correction to the site data based on the above. We cannot say what the magnitude of the

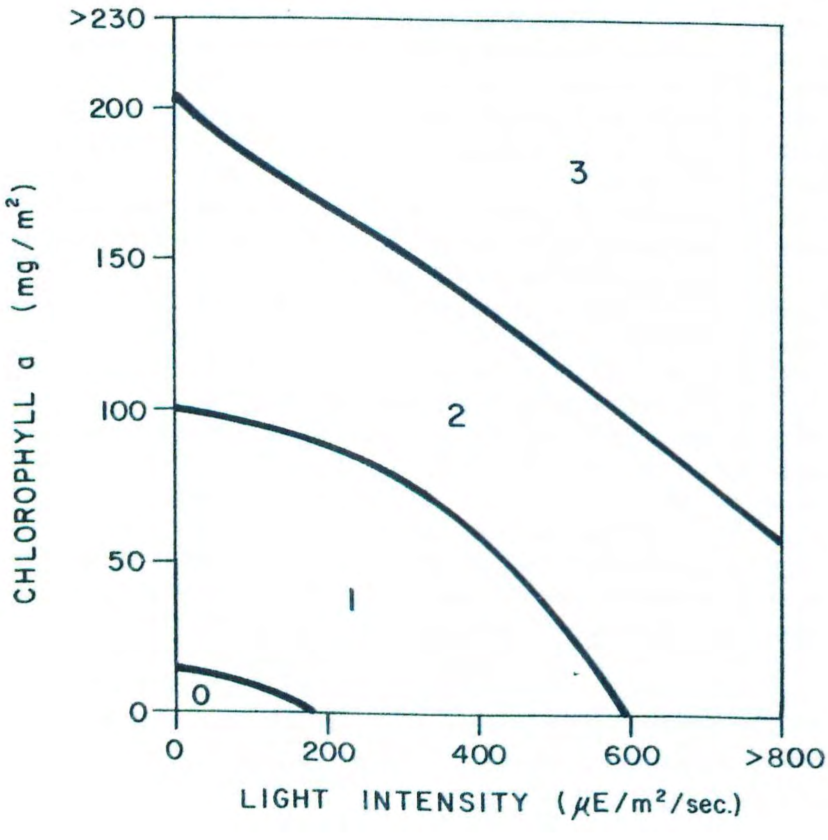

Figure 2. Value index matrix for the primary production parameter.

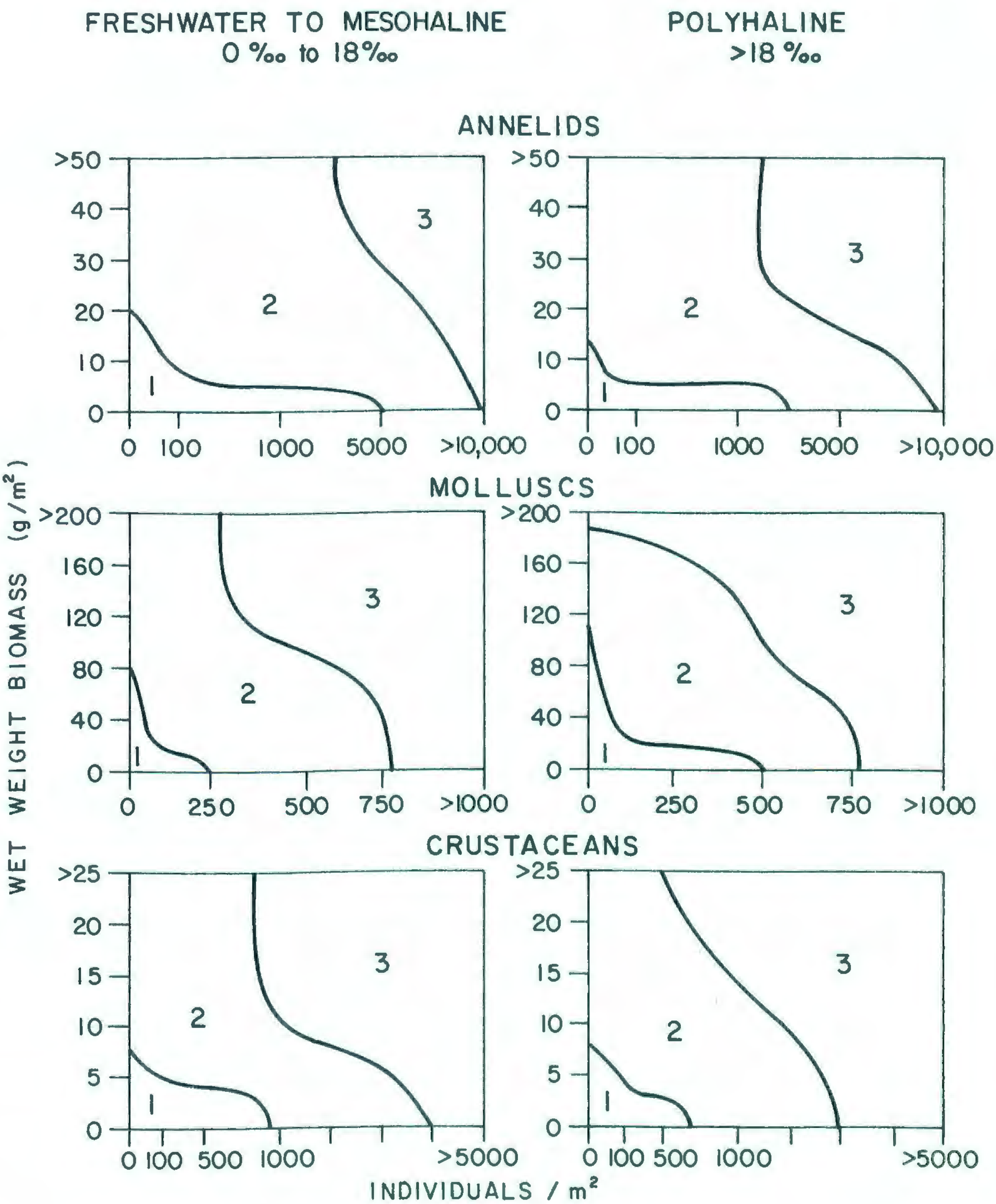

Figure 3. Value index matrices for the support population parameters. A zero value index would occur when no annelids, molluscs, or crustaceans are found.

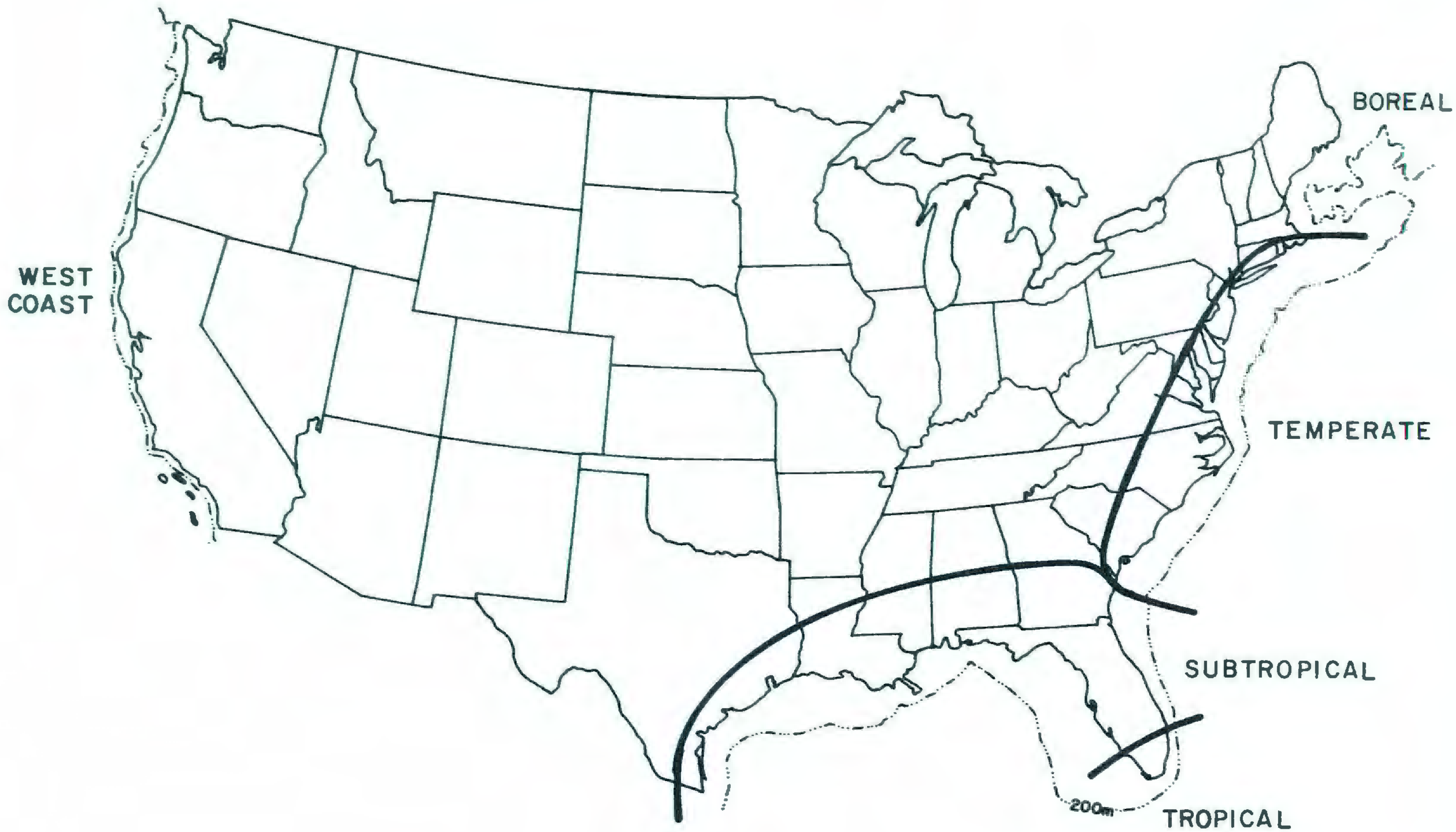

Figure 4. Geographic regions around the country that will affect the value index interpretation.

correction should be but it should tend to lower the value for boreal abundance, boreal biomass, and west coast biomass, and should raise the value for west coast abundance, tropical abundance and tropical biomass. The logic for this follows from the reference point on which the value indices are based.

For example; if a annelid abundance of 5000 ind/m^2 and biomass of 25 g/m^2 were found on an intertidal flat in Maine the value index, Figure 3, would consider this flat marginal between 2 and 3. However, the value index was based on a temperate and subtropical situation where values of 5000 ind/m^2 and 25 g/m^2 of annelids would be very much above average and the habitat would be a 3. In Maine these values are not exceptional and the value index should be lowered to a 2.

Seasonality also affects the abundance and biomass of support populations. To account for seasonality seasonal sampling is optimal (fall, winter, spring, summer). Then annually averaged data can be used to estimate the value index. Second to annual data are data collected during the time of peak abundance and biomass usually in the spring or fall in temperate, subtropical, tropical regions, and summer in boreal and west coast regions. The value index figures are based mainly upon annually averaged data and to a lesser extent on seasonal data.

Method for collection of field data are described in Appendix B. Once collected and processed the data are used to enter the value index figures (Figure 3). For example, if the following data were collected from a polyhaline habitat;

	Abundance/m^2	Biomass g/m^2
Annelids	1000	11
Molluscs	200	1
Crustaceans	550	3

the value indices would be,

Annelid - 2, Mollusc - 1, and crustacean - 2. These values would then be entered on the habitat evaluation Form FD (Appendix C).

PART III: APPLICATION OF METHODOLOGY AND EVALUATING RESULTS

The completed evaluation

When the project area evaluation is completed the following data forms (form Appendices A and C) should be as completely filled out as possible;

Form PD - Project description
Form SD - Site description
Form FD - field data

without all of these forms you cannot proceed with the evaluation.

For interpretations of the evaluation forms we must return to the management objectives that identified the need for applying the methodology. Restated, the basic goals were:

- Comparing habitats within a project site for baseline conditions.
- Comparing alternate project sites.
- Projecting habitat modifications from a project.
- Planning mitigation effort.

Most environmental assessment documents will include some aspect of all four of these basic goals. For a particular project, one, or possibly more, of these goals will be of primary interest. The application of the methodology will be discussed emphasizing each of the four goals.

Comparing habitats within a project site for baseline conditions

Baseline data collection is intended to provide an understanding of what the existing value is for the various habitats present in the project area. Each habitat identified within the project area should have the same level of effort applied in terms of field sampling. This will eliminate bias from an imbalance in the amounts of data and allow for a more accurate comparison of habitats.

All habitats, as described in Cowardin, et al. (1979), should be ranked based on the percent that each is of the total project area (data on Form SD), from highest to lowest. Value indices for each habitat are then listed in Table 1. From this table relative value of each habitat can be compared and discussed for each parameter.

Table 1. Evaluation of habitats within a project site for baseline conditions.

	Habitat	% of Project Area	Primary Producers	Annelids	Molluscs	Crustaceans	Comments
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

Consideration needs to be given to the percentage distribution of habitats. If all habitats are about the same percentage of the total project area then the value indices carry about the same weight. Should one habitat dominate then special consideration need be given to its overall value index standing with the other habitats. For example, should the dominant habitat have a lower relative value compared to the other habitats, the less extensive habitats become more important to protect from project impacts. Conversely should the dominant habitat have a higher relative value, project impacts need to be considered the area of this habitat effected.

Interpretation of the evaluation methodology for baseline conditions should include discussion of:

- habitats of uniformly low relative value.
- habitats of uniformly high relative value.
- juxtaposition and distribution of habitats.
- areal extent of habitats.
- habitats identified as critical to the ecological character of the area.

If possible baseline data should be collected over a period of years to get an understanding for the natural changes that may occur within the project area and how consistent the relative value of the habitats are. Keep in mind if data is collected over time it should be at the same seasons and same level of effort.

Comparing alternate project sites

Many times several alternate routes are possible for a given highway project. It is often desired to know which route is least disruptive to the environment. The evaluation methodology gives managers the basic data to make routing decisions by comparing the various sites using a standard set of criteria. For evaluating several project sites the same ground rules apply as those for within project area evaluation (see previous section).

Each alternate project site should be evaluated using Table 1 to identify habitats and their relationships within a particular project area. After each alternate site is evaluated in this manner an overall assessment needs to be made of all sites and habitats. The simplest and most straightforward case would be for each site to have each habitat in the same proportion. Each alternative site would then be directly comparable. For most projects this will not likely be the case, so a means of overall site evaluation needs to be derived from the value indices of all habitats at a particular site. A simple proportion weighted sum for each of the evaluation parameters serves this purpose. For example, if a project site had the following habitats and value index for primary producers:

Habitat	% of Project Area	Value Index Primary Producers
Bar disconnected from shoreline	10	2
Fringing tidal flat	10	3
Seagrass bed	20	3
Shallow flats	60	2

Then the overall value index for primary producers at the site would be:

$$
\begin{array}{r}
.10 \times 2 = 0.2 \\
.10 \times 3 = 0.3 \\
.20 \times 3 = 0.6 \\
.60 \times 2 = 1.2 \\
\hline
1.00 \qquad 2.3^{*}
\end{array}
$$

This proportion weighted sum would then be calculated for each evaluation parameter and entered in Table 2.

This approach is intended to give an overall impression of relative project site value. There may be unique features of an area that would be masked by this approach (i.e. critical habitat). It is then important to develop a narrative that describes and compares any outstanding character of a project site. Interpretation of alternate site evaluation needs to be discussed in light of:

- sites of uniformly high relative value
- sites of uniformly low relative value
- juxtaposition of sites
- sites with identified critical value

Data collected for evaluating alternate project sites must be collected at the time, within a period of days. At very worst data from the same season could be used. Alternate sites cannot be compared using data from different seasons or the same season in different years. Seasonality and natural population dynamics preclude any meaningful evaluation with any data other than the same season the same year.

Projecting habitat modifications from a project

Projecting what the habitat modifications will be from a project requires an understanding of the environmental effects associated with each phase of project construction. The timetable for construction

* This is the only place where a decimal place is carried in the Value Index.

Table 2. Evaluation of alternate project sites based on proportion weighted sum of value indices.

	Weighted Value Index					
	Project Site	Primary Producers	Annelids	Molluscs	Crustaceans	Comments
1						
2						
3						
4						
5						

events, part of Form PD, provides a format for listing events that may cause impacts. An understanding must be developed as to which habitats are to be affected, the expected impacts, and the area of habitat to be affected. Analysis of project construction plans and project map should provide the basic data needed to obtain this understanding.

For each site under consideration a survey of baseline conditions is needed (follow guidelines previously provided). The baseline condition is the reference point from which project impacts are measured. For applying this use of the evaluation methodology it is necessary for the evaluator to be familiar with general ecological principles and how construction activities will affect the environment. A basic understanding is provided in the literature review of tidal flats (Diaz, et al., 1981b).

Since projection of acute impacts are being made a scale for assessing the change to habitat value is needed. For lack of quantitative data on impact effects on the value index, the following scale has been arbitrarily set, based on the percentage of a particular habitat that is affected:

Area of Habitat Affected	Change in Value Index*
95 - 100%	-3.0
75 - 94%	-1.5
50 - 74%	-1.0
25 - 49%	-0.5
0 - 24%	0.0

Unless the character of the habitat is permanently changed the loss in the value index is temporary. The value index for any evaluation parameter would have a recovery time associated with it that depends upon the impact and type of habitat. Keep in mind these are predicted changes.

Data from Form PD, Form SD, and Table 1 need to be combined into Table 3. The changed value indices, which are the value indices from Table 1 minus the change in value index from percent habitat affected, are then summed by proportional weighting as done for Table 2. This provides an overall impression of project impacts at a site.

For interpreting projected changes in relative habitat value it is necessary to pay particular attention to:

- general magnitude of habitat modification
- patterns of habitat modification
- extent to which each habitat is modified

* Value indices less than zero are to be considered equal to zero.

Table 3. Projecting habitat modifications expected from a project.

Construction Events							
Impact Expected	Habitat Effected	% of Habitat Area Effected	Change in Value Index	Changed Value Index			
				Primary Producers	Annelids	Molluscs	Crustaceans

- severity of habitat modification
- duration of modification
- recovery from acute impacts
- disturbance of critical habitat

Planning mitigation effort

Mitigation for construction activities involving nonvegetated intertidal wetlands has not been practiced. Mitigation has traditionally involved only emergent wetlands or marshes. Consequently guidelines nor precedence exist when it comes to intertidal habitats. The main concern in mitigation is what constitutes a justifiable tradeoff of habitats or habitat area.

The evolution methodology may be of help in determining the need for mitigation and the best habitats that should be the object of a mitigation effort. The need for mitigation can be determined in two ways, either from projected habitat modification analysis or comparison of preconstruction and postconstruction evaluations. In either case a change in relative habitat value is obtained. If the change is of sufficient magnitude, as prescribed by the management process, then the habitat modifications are not acceptable without mitigation. If mitigation is required then the methodology can be used to identify those habitats and areas most beneficial to protect or develop. Guidelines for mitigations cannot be provided. Each project must be assessed on its own in relation to the specific objectives and management goals for the local environment.

In planning a mitigation effort it is necessary to consider:

- relative value of habitat lost
- relative value of habitat preserved or developed
- if habitat is developed consideration need be given to the relative value of the habitat that is displaced in development of new habitat

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APPENDIX A:

PROJECT DESCRIPTION FORMS

The forms described here are intended to provide a standardized approach to identifying the character of the nonvegetated intertidal wetlands and listing of the expected project impacts and changes. Site visits are required for making some observations. Topograhic and Navigation charts of aerial photographs should be sufficient for determining the area of various intertidal and subtidal habitats present in the project area. Engineering data from project blueprints will provide the necessary information for predicting what changes are expected in the intertidal areas.

FORM PD

PROJECT DESCRIPTION FOR HABITAT EVALUATION

Project Code Number: ______________________________

Project: ______________________________

____

Evaluator: ______________________ Date: __________

Location (Supply Map if possible): ______________________________

Specific location: ______________________________

____

Water Body(s): ______________________________

Project Boundaries (supply map):

On a project map indicate the following:

Delineate areas of acute impact. These are areas where the habitat will be eliminated or change drastically from construction activities.

Delineate areas of potential impact. These are areas where the habitat may be temporarily disturbed from construction activities or gradually effected after the project's completion.

Delineate areas of no probable impact.

		Percentage of Total
Total project area		100%
Area of acute impacts		
Area of potential impact		
Area of no probable impact		

Project Description:

Type of project:

Types of impacts anticipated:

Hydrological effects

- [ ] Impoundment
- [ ] Reduction of flow
- [ ] Enhancement of flow
- [ ] Change in mean water level
- [ ] Change in tidal amplitude
- [ ] Change in flushing time
- [ ] Draining
- [ ] Channelling
- [ ] Modification of circulation

Substrate effects

- [ ] Increase in sedimentation
- [ ] Increase in suspended solids or turbidity
- [ ] Dredging or excavation for fill
- [ ] Dredging for deepening water
- [ ] Dredged material disposal
- [ ] Filling
- [ ] Erosion

Chemical effects

- [ ] Salinity increase
- [ ] Salinity decrease
- [ ] Lowering of dissolved oxygen
- [ ] Increase in dissolved oxygen
- [ ] Heavy metals contamination
- [ ] Toxic organics contamination
- [ ] Increased nutrient loading

TIMETABLE FOR CONSTRUCTION EVENTS THAT MAY CAUSE IMPACTS

Event	Start	End	Duration	% of Total Project Effort	Impact* Expected	Habitat** Impacted	Area of Habitat Impacted	What % of total habitat is impacted

* There may be more than one expected impact per construction event.

** There may be more than one habitat involved with each expected impact or construction event.

FORM SD
SITE DESCRIPTION FOR HABITAT EVALUATION

Project Code Number: ______________________________

Project: ______________________________

Evaluator ______________________________

Date: ______________________________

Type of Intertidal and Subtidal Nonvegetated Wetland Habitats Present in Project Area:

Tide Stage During Visit: ______________ Time: ______________

Salinity: ______________

		Sediment Type	Total Area	% of Total Area	% in zone of acute impact	% in zone of potential impact	% in zone of no impact
	Bar (disconnected from shoreline)						
	Tidal flat (>5 m width)						
	Fringing tidal flat (<5 m width)						
	Periphery of vegetated wetland						
	Creek Bank						
	Sand beach						
	Hard Substrate (Rock, Jetty)						
	Shallow flat (<1 m deep at low tide)						
	Deeper subtidal (>1 m at low tide)						
	Seagrass bed						
	Natural channel						
	Dredged channel						
	Disposal area						
	Other						
	Totals			100			

Notes

Biological Characteristics:	Extensive	Widespread	Patchy	Sparse
Interspersed marsh plants				
Seagrass beds				
Macroalgae (sea weed, sea lettuce)				
Microalgae mats (suggested by brown or green color on sediment surface)				
Oyster rock				
Other				

Other observed marine life:

Other obvious marine life (tracks, tubes):

Presumed animal utilization (migratory birds, fish):

Human Uses:

Observed or apparent direct utilization of habitats within project area.

- [ ] Recreational fishing, crabbing, shellfishing
- [ ] Commercial fishing, crabbing, shellfishing
- [ ] Public access
- [ ] Private access
- [ ] Boat dock
- [ ] Beach
- [ ] Bird watching
- [ ] Other

	Adjacent land use:	Predominates	Widespread	Uncommon
	Undeveloped woodland			
	Marsh			
	Agriculture			
	Industrial			
	Commercial			
	High density residential			
	Low density residential			
	Other			

APPENDIX B

SUGGESTED FIELD METHODS FOR HABITAT EVALUATION

I: Primary Producers

To evaluate a site for primary producers the principal parameters of concern are chlorophyll-a concentration (an indicator of algal biomass) and light availability. In general, low levels of chlorophyll-a result in low productivity, high levels of chlorophyll-a in high productivity. However, productivity is also dependent on the amount and quality of light energy available to the plants. Light availability is a function of water depth, turbidity, and local weather conditions.

It is imperative that measurements of chlorophyll-a and light not be made during or immediately (1-2 days) after storms. During such periods the parameter values would be temporarily modified that an underestimate of the primary production potential would result.

Field Procedures

1. A representative sample site must be chosen. Since a given area has variable elevation and therefore different water depths, and since water depth varies at a given point with tidal changes, we recommend selecting a sample site as follows; 1) at high tide, measure the water depth of the shallowest and deepest parts of the area to be evaluated, 2) take an average of these depths, and select at least two stations at that average depth. For example, if the deepest station is 100 cm, and the shallowest station is 10 cm, two study sites at a depth of 55 cm should be chosen. Light and chlorophyll-a samples should be taken at each station.

2. Measure light levels at the chosen stations at low tide, at the sediment surface. Use an instrument which measures photosynthetically active radiation (PAR), i.e. light wavelengths between 400 and 700 μm. (Li-Cor model Li-185A was used in this study). Microalgal communities have light saturation levels between 154-1200 $\mu E/m^2/sec$. Low tide measurements represent the maximum light available. If the community is undersaturated at low tide, it will be even more light-limited at high tide, with a commensurate decrease in productivity. Stations which are saturated at low tide may not be saturated at high tide, but such areas may be very productive over a short period of time. The relative productivity then depends on the amount of algae (chlorophyll a) present.

3. Make the light measurement within an hour of noon, standard time. This is, again, the time when maximum light penetration is achieved, but some time reference point is needed, since light penetration

depends on sun angle. The units for measuring light should be micro Einstein's per metre squared per second.

4. Four (4) surface sediment samples of 4 cm^2, 2 cm on an edge and no deeper than 1 cm, should be collected at each sample station for chlorophyll-a analysis. The two sediment samples should be placed on ice until return to the laboratory for analysis. Chlorophyll-a analysis has been extensively investigated, and many similar methods are available (Vollenweider 1974, Lorenzen 1967, Strickland and Parsons 1968, Moss 1967a, 1967b). To convert the data to metre squared take the average of the four samples and multiply by 2500 (this is for a 4 cm^2 sample).

5. Be aware of seasonal effects; the value index table was compiled for summer (June-August) because 1) more data are available from the period, and 2) most evaluations will take place then. Evaluations made earlier than April or later than October may give a lower habitat value index.

6. Sample during non-storm periods so that representative light and chlorophyll measurements can be made. Also, since cloudy days may decrease light 25-90%, sample on sunny days.

II. Support Populations

To evaluate a site for support populations the principal parameters of concern are number of individuals and wet weight biomass per metre squared for total annelids, molluscs, and crustacea. These coarse groupings are necessary to facilitate habitat evaluation. There are literally hundreds of species that make up each of these major taxonomic groups and their taxonomy is time consuming. For the most part all the species during some stage of their life history provide important trophic support to fisheries species. So a generalized overall approach to these major support populations (annelids, molluscs, crustaceans) is valid.

Field Procedures

1. After the major habitat groupings (sandbar, mudflat, seagrass beds) have been identified samples for support populations should be taken in each major habitat. A line transect of 80 ft. should be set in each habitat and 5 core samples taken on the transect at 20 ft. intervals. The core samples should be about 9 to 10 cm in diameter (3.5-4.0") and about 20 cm long. The core should be pushed 3/4 of the way into the sediment or about 15 cm. The core may be capped and slowly removed from the bottom or dug out.

2. The 5 cores are combined in an appropriately labelled bucket. The composite sample may be washed in the field or returned to the laboratory for washing. If returned to the lab or a delay is expected before the sample is washed it should be preserved immediately with 10% formalin. The sample should be gently washed through a 1.0 mm screen. After as much of the sediment as possible has been washed away whatever remains on the screen is transferred to a jar, labelled as to its

location, and preserved with 10% buffered formalin. Samples processed to this point may be stored and catalogued until time permits their further processing.

3. The organisms must be removed from the sieved remains and placed into one of three categories (annelids, molluscs, crustaceans). Miscellaneous groups should be ignored. The sample should be rewashed on a 1.0 mm screen to remove the formalin and placed in tap water. A small amount of the sample at a time should be sorted with the aide of a dissecting microscope. After completing a sample each major group should be counted and weighed to the nearest 0.1 g. If there will be a delay in weighing or it is desired to keep the picked samples for further analysis, they must be returned to 10% formalin, 70% ethyl alcohol, or 50% isopropyl alcohol.

4. The abundance and biomass data are then converted to a unit area of 1 metre. This is done by multiplying the number of cores by the area sampled per core and dividing into the number of individuals (or weight) in the sample. For example if a 10 cm diameter core (area of 78 cm^2 or 0.0078 m^2) was used and 5 cores made up a sample the conversion to metre squared data would be:

$$0.0078 \times 5 = 0.039$$

$$\frac{\text{Individuals or biomass in 5 cores}}{0.039} = \text{Ind./m}^2 \text{ or Bio./m}^2$$

Once the data are converted to m^2 they are ready to be used in the evaluation method.

REFERENCES

Lorenzen, C. J. 1967. Determination of chlorophyll and pheo-pigments: spectrophotometric equations. Limnol. Oceanogr. 12:343-346.

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Strickland, J. D. H. and T. R. Parsons. 1968. A practical handbook of seawater analysis. Bull. Fish. Res. Bd. Canada 167:1-311.

Vollenweider, R. A. 1974. A manual of methods of measurement of primary production in aquatic systems. IBP Handbook No. 12. Blackwell Scientific Pub. Oxford. 225 p.

APPENDIX C

FIELD DATA FORMS

The forms described here are for listing the value indices from the various habitats at a site. They also provide a summary or overview of the project for evaluation and management decisions.

FORM FD
HABITAT EVALUATION FIELD DATA SUMMARY

Project Code Number: ______________________

Project: ______________________

____

Evaluator: ______________________ Date: ____________

Intertidal Habitats Present in Project Area or Alternate Sites to be Evaluated (should correspond to habitats described on the Site Description for Habitat Evaluation form):

Is Particular Habitat Present at Sites

		1	2	3	4
Habitat 1					
Habitat 2					
Habitat 3					
Habitat 4					
Habitat 5					
Habitat 6					

Notes:

TABLE OF EVALUATION PARAMETERS AND VALUE INDICES
FOR ALL COMBINATIONS OF SITE AND HABITAT

Site						
Habitat						
Primary Producers						
Chlorophyll a mg/m^2						
Light Intensity $\mu E/m^2/sec$						
Value Index						
Support Populations						
Annelid Abundance Ind/m^2						
Annelid Biomass g/m^2						
Value Index						
Mollusc Abundance Ind/m^2						
Mollusc Biomass g/m^2						
Value Index						
Crustacean Abundance Ind/m^2						
Crustacean Biomass g/m^2						
Value Index						

APPENDIX D

Case Study

To better understand and approach the use of the evaluation methodology a case study has been developed. While the details of the construction activities and site character are hypothetical the data for habitat parameters are from real field situations and are not made up.

The Project

Access is planned from an existing highway to an ocean beach. The route of the new road will go over intertidal flats. The question raised is will the new road disturb the environment and what is the value of the intertidal areas that will be disturbed. The evaluation methodology is employed to identify the relative value of the intertidal habitats and predict what changes will occur from the new project. The time frame is such that there are six months to complete the evaluation.

Planning the Evaluation

With only six months for the evaluation it will be possible to collect, at most, data from two seasons, say spring and summer. However resources are such that only one sampling period is possible. This being the case spring would be the best time. Data are to be collected for all evaluation parameters.

The project description and site description forms are filled out after a preliminary visit to the site (see Sample PD and SD forms).

Field Data

Data were collected following the guidelines in Appendix B within each of the habitats identified in the project area. Primary Producer data are from a barrier sound in Sapelo Island, Georgia. Support Population data are from Albemarle Sound, North Carolina.

After the data are processed results are averaged and placed on the habitat evaluation field data summary form (see Sample FD form).

Habitat Evaluation

Since we are trying to find the relative value of our project site we transfer the value indices to Table 1, evaluation of habitats within a project site for baseline conditions. From this we see that the relative value of the area is highest for primary producers and generally low for support populations. The larger portion of the project area is fairly consistent in value, being moderate. Looking at where the impacts are expected (see timetable for construction events form PD), we can make predictions on the change in habitat value from the project by filling in Table 3, Projecting habitat modifications expected from a project.

The evaluation methodology predicts no change in the relative value of the habitats within the project area from any of the individual construction events. However, it is necessary to combine the impacts from individual construction events to get an overall assessment of the project. If the habitats are summed in terms of their area affected (from Table 3) the overall project change is:

Tidal flat	25%
Periphery flat	20%
Shallow flat	20%

There is still no predicted change in the relative value for the periphery flat fringing the marsh and the shallow flat, but the tidal flat habitat is changed. The value index for the tidal flat should be lowered by -0.5 to get the overall project impact. So the final overall predicted habitat condition for this case study is:

	Primary Producers	Annelids	Molluscs	Crustaceans
Tidal flat	2.5	0.5	0.5	0.5
Periphery flat	3	1	1	1
Shallow flat	2	2	1	2

Decision as to go ahead with the project or change the road design to avoid any loss of habitat value would then be based on this final matrix.

FORM PD

PROJECT DESCRIPTION FOR HABITAT EVALUATION

Project Code Number: Case Study

Project: Beach Access Road

Evaluator: ______________________ Date: ____________

Location (Supply Map if possible): Attached

Specific location: ______________________

Water Body(s): Atlantic Ocean, Sound

Project Boundaries (supply map):
Area 600' on either side of new roadway (See Map)

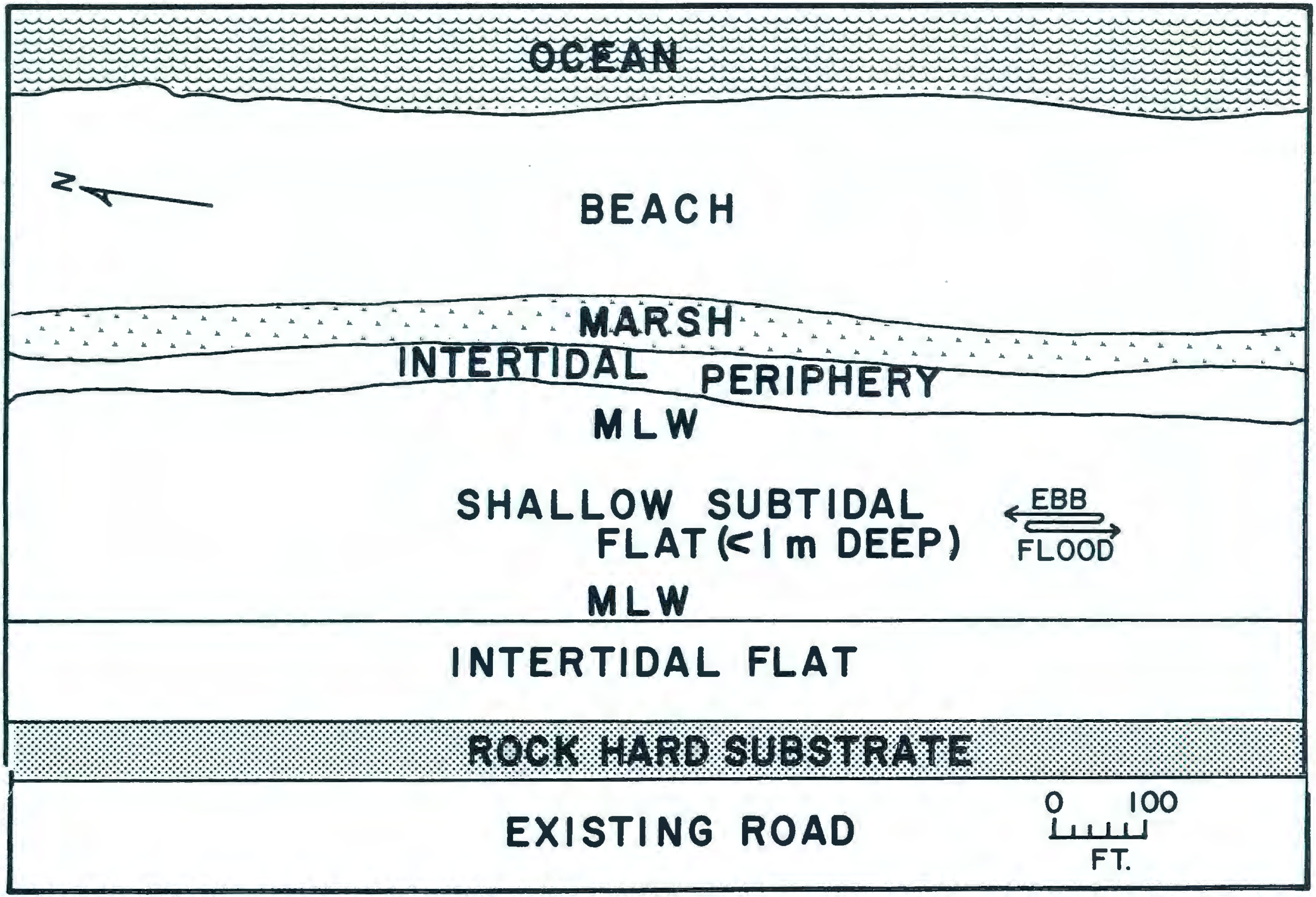
On a project map indicate the following:

Delineate areas of acute impact. These are areas where the habitat will be eliminated or change drastically from construction activities.

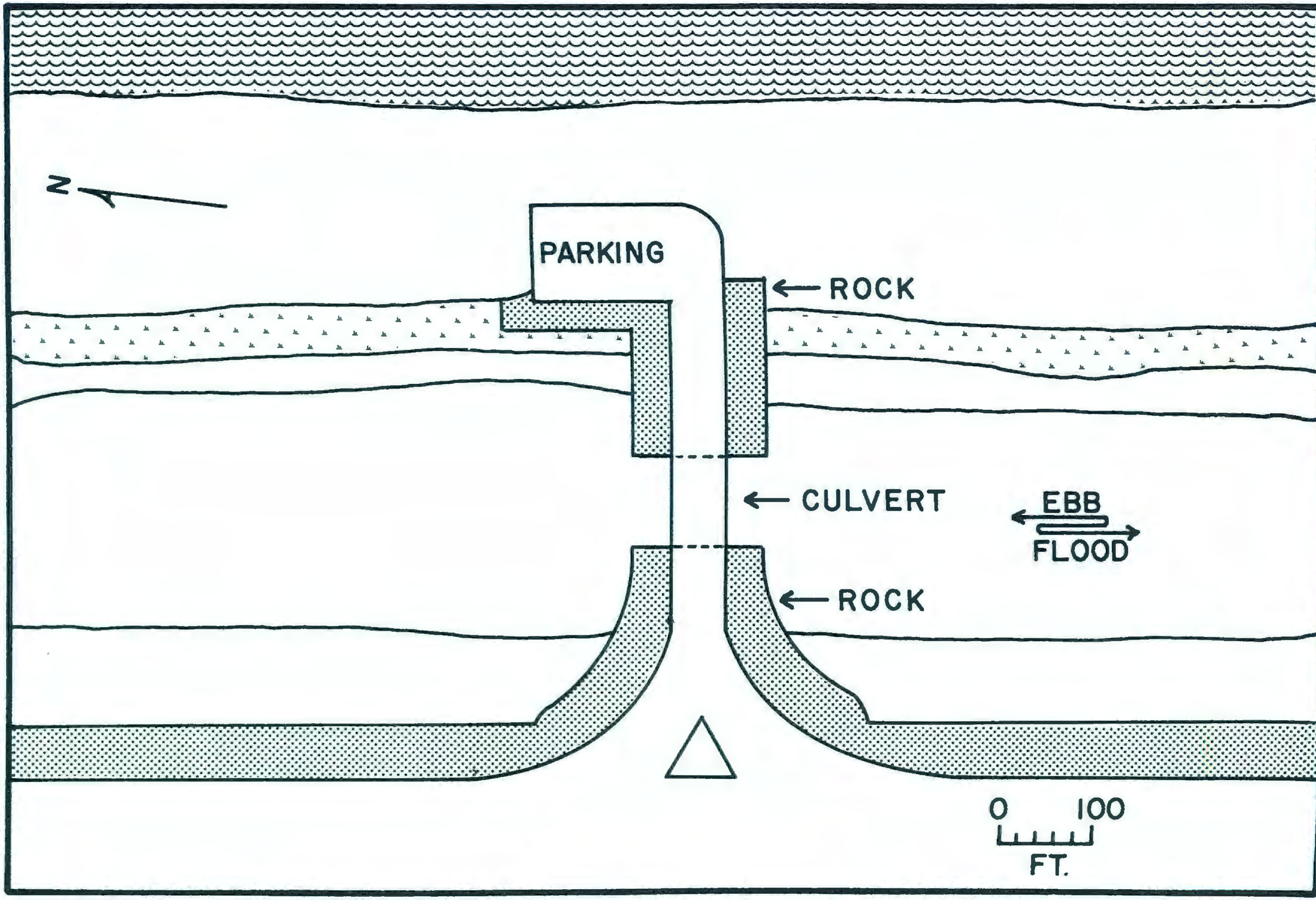
Delineate areas of potential impact. These are areas where the habitat may be temporarily disturbed from construction activities or gradually effected after the project's completion.

Delineate areas of no probable impact.

	yd²	Percentage of Total
Total project area	30,000	100%
Area of acute impacts	3,500	11.7
Area of potential impact	3,000	10.0
Area of no probable impact	23,500	78.3


OCEAN
N
BEACH
MARSH
INTERTIDAL PERIPHERY
MLW
SHALLOW SUBTIDAL FLAT (<1 m DEEP)
EBB
FLOOD
MLW
INTERTIDAL FLAT
ROCK HARD SUBSTRATE
EXISTING ROAD
0 100
FT.

Site Map



Project Map

Project Description:

Type of project: Road 60' wide over intertidal area
Culverts to allow flow North & South

Types of impacts anticipated:

Hydrological effects

- [ ] Impoundment
- [x] Reduction of flow
- [ ] Enhancement of flow
- [ ] Change in mean water level
- [ ] Change in tidal amplitude
- [x] Change in flushing time
- [ ] Draining
- [ ] Channelling
- [x] Modification of circulation

Substrate effects

- [ ] Increase in sedimentation
- [ ] Increase in suspended solids or turbidity
- [ ] Dredging or excavation for fill
- [ ] Dredging for deepening water
- [ ] Dredged material disposal
- [x] Filling
- [ ] Erosion

Chemical effects

- [ ] Salinity increase
- [ ] Salinity decrease
- [ ] Lowering of dissolved oxygen
- [ ] Increase in dissolved oxygen
- [ ] Heavy metals contamination
- [ ] Toxic organics contamination
- [ ] Increased nutrient loading

TIMETABLE FOR CONSTRUCTION EVENTS THAT MAY CAUSE IMPACTS

Event	Start	End	Duration	% of Total Project Effort	Impact* Expected	Habitat** Impacted	Area of Habitat Impacted	What % of total habitat is impacted
Filling			3 months	50	covering bottom	Tidal Flat	1340 yd²	20
						Periphery Flat	375	15
						Shallow Flat	1,960	8
Culvert Construction			2 months	40	Physical Disturbance	Shallow Flat	1,960	8
Rock Gambians			1 month	10	covering Bottom	Tidal Flat	335	5
						Periphery Flat	125	5
						Shallow Flat	980	4

* There may be more than one expected impact per construction event.

** There may be more than one habitat involved with each expected impact or construction event.

FORM SD

SITE DESCRIPTION FOR HABITAT EVALUATION

Project Code Number: Case Study

Project: Beach Access Road

Evaluator ____________________

Date: ____________________

Type of Intertidal and Subtidal Nonvegetated Wetland Habitats Present in Project Area:

Tide Stage During Visit: Low Time: ____________

Salinity: 24 ‰

		Sediment Type	Total Area yd^2	% of Total Area	% in zone of acute impact	% in zone of potential impact	% in zone of no impact
	Bar (disconnected from shoreline)						
X	Tidal flat (>5 m width)	Sandy	6,700	22	25	5	70
	Fringing tidal flat (<5 m width)						
X	Periphery of vegetated wetland	Sandy Mud	2,500	8	20	5	75
	Creek Bank						
	Sand beach						
X	Hard Substrate (Rock, Jetty)	Rock	1,200	4	30	5	65
X	Shallow flat (<1 m deep at low tide)	Sand	19,600	66	25	5	75
	Deeper subtidal (>1 m at low tide)						
	Seagrass bed						
	Natural channel						
	Dredged channel						
	Disposal area						
	Other						
	Totals		30,000	100			

Notes Small fringing marsh on east side of Sound

	Biological Characteristics:	Extensive	Widespread	Patchy	Sparse
X	Interspersed marsh plants		X		
	Seagrass beds				
	Macroalgae (sea weed, sea lettuce)				
X	Microalgae mats (suggested by brown or green color on sediment surface)			X	
	Oyster rock				
	Other				

Other observed marine life: Small fish and crabs seen in shallows. Barnacles and snails on Rocks

Other obvious marine life (tracks, tubes): Many worm tubes in intertidal

Presumed animal utilization (migratory birds, fish): Some bird tracks in marsh and intertidal

Human Uses:

Observed or apparent direct utilization of habitats within project area.

- [x] Recreational fishing, crabbing, shellfishing
- [ ] Commercial fishing, crabbing, shellfishing
- [ ] Public access
- [ ] Private access
- [ ] Boat dock
- [ ] Beach
- [x] Bird watching
- [ ] Other

Adjacent land use:

		Predominates	Widespread	Uncommon
	Undeveloped woodland			
	Marsh			
	Agriculture			
	Industrial			
	Commercial			
	High density residential			
	Low density residential			
X	Other Barrier Island	X		

FORM FD
HABITAT EVALUATION FIELD DATA SUMMARY

Project Code Number: Case Study

Project: Beach Access Road

Evaluator: ____________ Date: ____________

Intertidal Habitats Present in Project Area or Alternate Sites to be Evaluated (should correspond to habitats described on the Site Description for Habitat Evaluation form):

Is Particular Habitat Present at Sites

		1	2	3	4
Habitat 1	Tidal Flat	X			
Habitat 2	Periphery Flat	X			
Habitat 3	Rock	X			
Habitat 4	Shallow Flat	X			
Habitat 5					
Habitat 6					

Notes: Rocky areas are all manmade and not very extensive so they will not be included in the field sampling.

TABLE OF EVALUATION PARAMETERS AND VALUE INDICES
FOR ALL COMBINATIONS OF SITE AND HABITAT

Site	1	1	1			
Habitat	1	2	4			
Primary Producers						
Chlorophyll a mg/m^2	206	221	40			
Light Intensity $\mu E/m^2/sec$	1000	1000	800			
Value Index	3	3	2			
Support Populations						
Annelid Abundance Ind/m^2	1120	650	3650			
Annelid Biomass g/m^2	7.3	6.2	11.1			
Value Index						
Mollusc Abundance Ind/m^2	60	70	80			
Mollusc Biomass g/m^2	4.2	4.1	3.0			
Value Index						
Crustacean Abundance Ind/m^2	10	200	3000			
Crustacean Biomass g/m^2	.1	1.0	3.1			
Value Index						

Table 1. Evaluation of habitats within a project site for baseline conditions (see pg. 15).

	Habitat	% of Project Area	Primary Producers	Annelids	Molluscs	Crustaceans	Comments
1	Tidal Flat	22	3	1	1	1	Annelid value bordering on 2
2	Periphery Flat	8	3	1	1	1	Annelid value bordering on 2
3	Rock	4	-	-	-	-	Not sampling
4	Shallow Flat	66	2	2	1	2	
5							
6							
7							
8							
9							
10							

Table 3. Projecting habitat modifications expected from a project (see pg. 20).

Construction Events							
Impact Expected	Habitat Effected	% of Habitat Area Effected	Change in Value Index	Changed Value Index			
				Primary Producers	Annelids	Molluscs	Crustaceans
Filling	Tidal Flat	20	0	3	1	1	1
	Periphery Flat	15	0	3	1	1	1
	Shallow Flat	8	0	2	2	1	2
Culvert	Shallow Flat	8	0	2	2	1	2
Rock Gabions	Tidal Flat	5	0	3	1	1	1
	Periphery Flat	5	0	3	1	1	1
	Shallow Flat	4	0	2	2	1	2

*U.S. GOVERNMENT PRINTING OFFICE: 1982 361-428/2207 1-3

FEDERALLY COORDINATED PROGRAM (FCP) OF HIGHWAY RESEARCH AND DEVELOPMENT

The Offices of Research and Development (R&D) of the Federal Highway Administration (FHWA) are responsible for a broad program of staff and contract research and development and a Federal-aid program, conducted by or through the State highway transportation agencies, that includes the Highway Planning and Research (HP&R) program and the National Cooperative Highway Research Program (NCHRP) managed by the Transportation Research Board. The FCP is a carefully selected group of projects that uses research and development resources to obtain timely solutions to urgent national highway engineering problems.*

The diagonal double stripe on the cover of this report represents a highway and is color-coded to identify the FCP category that the report falls under. A red stripe is used for category 1, dark blue for category 2, light blue for category 3, brown for category 4, gray for category 5, green for categories 6 and 7, and an orange stripe identifies category 0.

FCP Category Descriptions

1. Improved Highway Design and Operation for Safety

Safety R&D addresses problems associated with the responsibilities of the FHWA under the Highway Safety Act and includes investigation of appropriate design standards, roadside hardware, signing, and physical and scientific data for the formulation of improved safety regulations.

2. Reduction of Traffic Congestion, and Improved Operational Efficiency

Traffic R&D is concerned with increasing the operational efficiency of existing highways by advancing technology, by improving designs for existing as well as new facilities, and by balancing the demand-capacity relationship through traffic management techniques such as bus and carpool preferential treatment, motorist information, and rerouting of traffic.

3. Environmental Considerations in Highway Design, Location, Construction, and Operation

Environmental R&D is directed toward identifying and evaluating highway elements that affect the quality of the human environment. The goals are reduction of adverse highway and traffic impacts, and protection and enhancement of the environment.

4. Improved Materials Utilization and Durability

Materials R&D is concerned with expanding the knowledge and technology of materials properties, using available natural materials, improving structural foundation materials, recycling highway materials, converting industrial wastes into useful highway products, developing extender or substitute materials for those in short supply, and developing more rapid and reliable testing procedures. The goals are lower highway construction costs and extended maintenance-free operation.

5. Improved Design to Reduce Costs, Extend Life Expectancy, and Insure Structural Safety

Structural R&D is concerned with furthering the latest technological advances in structural and hydraulic designs, fabrication processes, and construction techniques to provide safe, efficient highways at reasonable costs.

6. Improved Technology for Highway Construction

This category is concerned with the research, development, and implementation of highway construction technology to increase productivity, reduce energy consumption, conserve dwindling resources, and reduce costs while improving the quality and methods of construction.

7. Improved Technology for Highway Maintenance

This category addresses problems in preserving the Nation's highways and includes activities in physical maintenance, traffic services, management, and equipment. The goal is to maximize operational efficiency and safety to the traveling public while conserving resources.

0. Other New Studies

This category, not included in the seven-volume official statement of the FCP, is concerned with HP&R and NCHRP studies not specifically related to FCP projects. These studies involve R&D support of other FHWA program office research.

* The complete seven-volume official statement of the FCP is available from the National Technical Information Service, Springfield, Va. 22161. Single copies of the introductory volume are available without charge from Program Analysis (HRD-3), Offices of Research and Development, Federal Highway Administration, Washington, D.C. 20590.