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DREDGING IN ESTUARIES

Guides Manual

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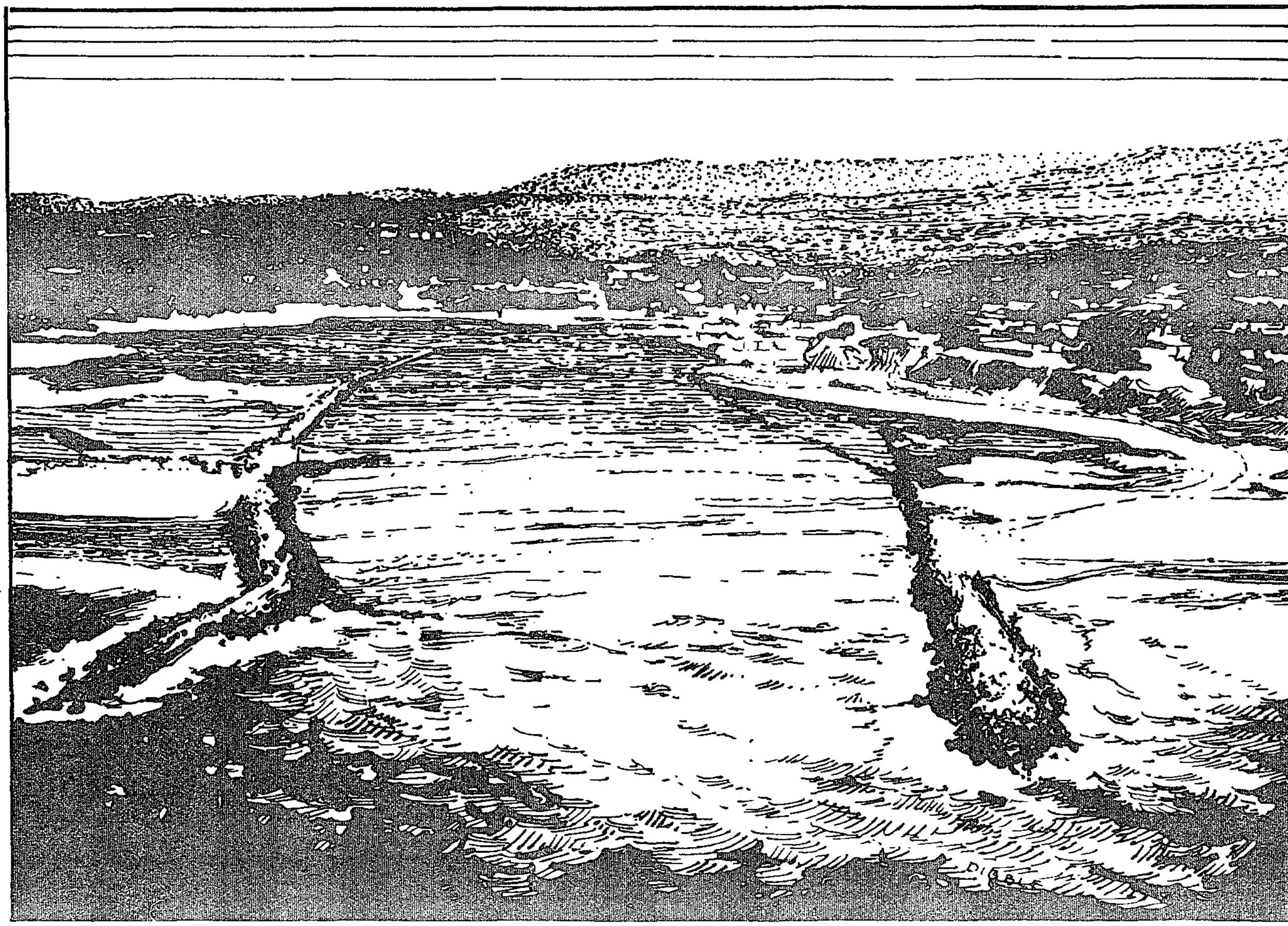

National Science Foundation. Research Applied to National Needs (RANN)

A Guide for Review of Environmental Impact Statements

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DREDGING IN ESTUARIES

A Guide for Review of Environmental Impact Statements

GUIDES MANUAL

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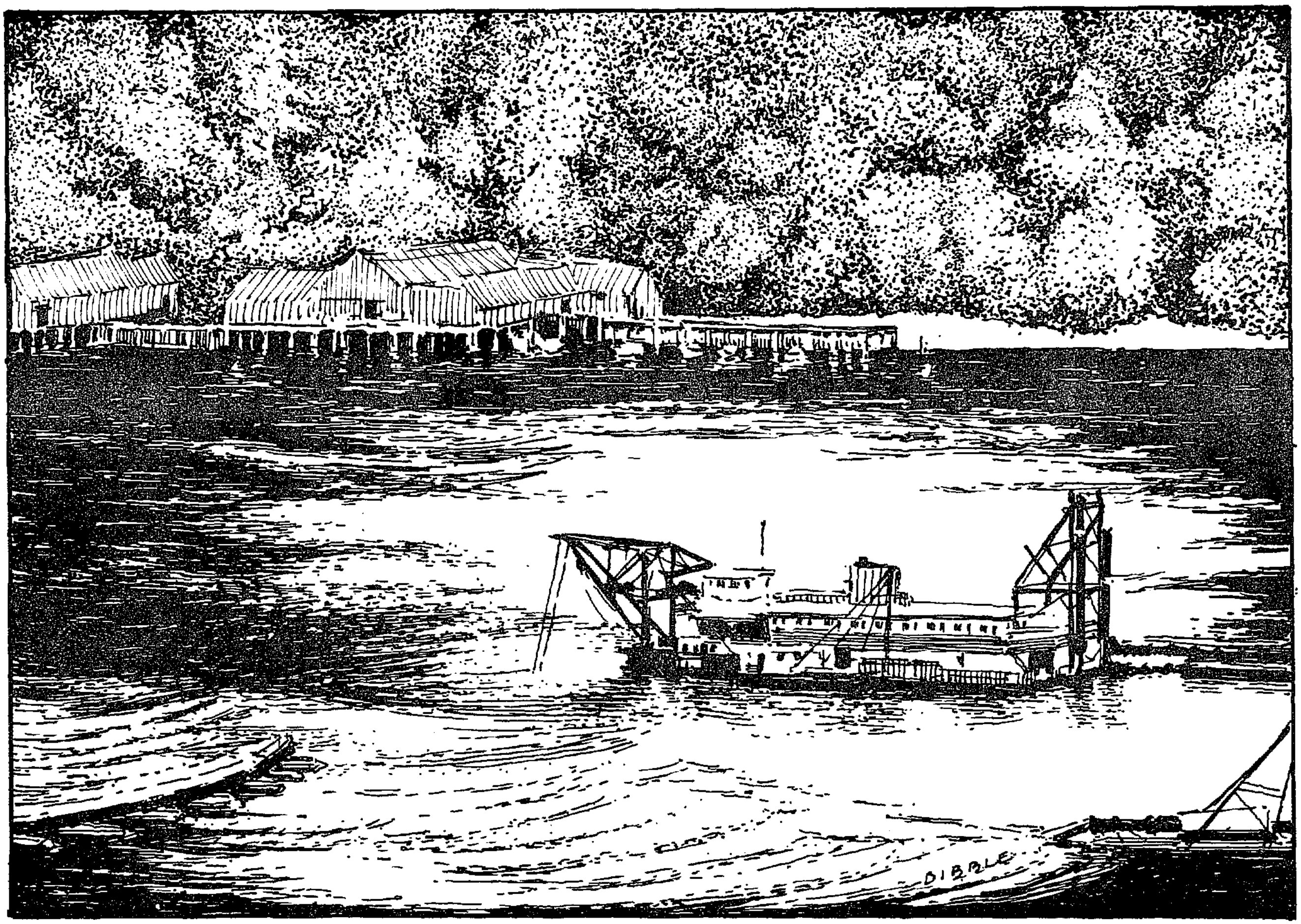

1. Introduction

1.1. PURPOSE

The National Environmental Policy Act (NEPA) establishes continuing environmental responsibilities for agencies of the Federal Government. These agencies are required to "improve and coordinate Federal plans, functions, programs and resources"[1] to fulfill these responsibilities. NEPA specifically requires the preparation of environmental impact statements (EIS's) for dredging operations which require Federal action.[2]

The primary purpose of this manual is to provide guidance for the review of EIS's which have been prepared in accordance with the NEPA for dredging actions in estuaries. Before outlining the format of the material presented in this manual, it seems appropriate to first examine some of the fundamental concerns of the NEPA *vis a vis* the preparation of an EIS for dredging in estuaries.

1.2. NEPA AND CEQ GUIDELINES

General guidelines for the preparation of EIS's have been set forth by the Council on Environmental Quality (CEQ). In addition, Federal, State, and local agencies have also issued guidelines for the preparation of EIS's. Since many of these guidelines set forth the procedural requirements of these individual agencies it was not necessary to prepare a manual for the review of EIS which details all of the existing agency guidelines. In our opinion, however, it was necessary to provide review guidelines which would lead to a thorough and critical examination of whether the provision of NEPA and the CEQ Guidelines have been met. Consequently, we have restricted the scope of this manual to review for compliance with the intent of NEPA and the CEQ Guidelines.

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1. The National Enviornmental Policy Act (PL 91-190, 42 U.S.C. 4321 *et seq.*) Sec. 101(b).
2. The National Environmental Policy Act (*loc. cit.*) Sec. 102(2)(C)

It is important to note that EIS's which have been prepared under NEPA should reflect the efforts of Federal agencies to meet the broader environmental responsibilities stated in NEPA. Thus, when we speak of impact assessment and statements, we refer not merely to procedural requirements of the CEQ Guidelines,[3] but also to activities and documents which demonstrate how "Federal plans, functions, programs and resources"[4] are being improved and coordinated to fulfill the intent of the NEPA. From this view, environmental impact statements (and the documents, policies and techniques upon which they are based) are more than descriptions of environmental impacts; they are documents which, through their wide circulation and review within society, expose the proposed actions of Federal agencies to critical and constructive review and, in so doing, help to insure that their efforts conform to the intent of NEPA.

1.3. SUGGESTIONS FOR EIS REVIEW

1.3.1. The Role of Reviewers

The role of EIS reviewers is an essential element within the environmental impact assessment process and within the broader social process of environmental management. As a group, EIS reviewers have the following desirable characteristics which differ from those of individuals who usually prepare any particular impact statement:

1) they represent a wide range of different interests, attitudes, abilities, and approaches, and
2) they are not necessarily constrained by any single set of institutional guidelines or procedures.

3. The Federal Register, Vol. 38, (147), Part II, Aug. 1, 1973.
4. The National Environmental Policy Act (*loc. cit.*) Sec. 101(b)

Because of these characteristics, reviewers as a group may provide important checks and balances. In this system of checks and balances, they may challenge procedures imposed on the EIS process through agency policies; they may raise new issues and concerns; and they may expose continuing conflicts[5] as seen from a range of perspectives. We consider these characteristics and checks and balances to be desirable, and thus this manual does not attempt to "standardize" the EIS review process or to supplant existing agency guidelines. We believe that the diverse interests, approaches, attitudes, commitments, backgrounds, and constraints of reviewers are important and even essential aspects of the EIS review process.

Reviewers, however, often suffer from the following deficiencies:

1) they have very little time to review impact statements and
2) they have limited resources with which to gather the environmental and technical information which is essential to the review process.

This manual seeks to minimize these deficiencies without destroying the desirable characteristics previously mentioned. This material seeks to expose reviewers to a number of environmental concerns. It attempts to provide a number of general suggestions; to describe some fundamental environmental processes and systems;, to identify a variety of techniques and approaches and to provide source material for a wide range of environmental concerns. In summary, this manual attempts to provide guidance which is intended to increase the efficiency and effectiveness of reviewers by complementing the reviewers' diverse abilities. In the final analysis, of course, reviewers must state their own cases as they themselves best see it by drawing upon all of their resources.

5. The National Environmental Policy Act (*loc. cit.*) Sec. 102(2)(D).

1.3.2. Confronting Massive Technical Information

Often reviewers are confronted with massive amounts of environmental data and technical information which they may find extremely difficult to evaluate in terms of its adequacy and relevancy to the NEPA. We cannot provide a simple step by step procedure for this difficult task; however, we may offer some general suggestions. To begin, let us offer the following assumptions:

1) most technical material and environmental data should be in the EIS for specific reasons, and
2) the principal reason for presenting environmental data and technical information is to assess a potential impact.

Based upon these assumptions the reviewer should ask the following: what potential impact do these environmental data and technical information seek to assess? If the answer to this question is not clearly described within the impact statement, then the reviewer certainly has grounds for criticizing the EIS . If the potential impact may be identified, then, reviewers need to assess this impact within their own capabilities. If the reviewers are qualified and if they perceive the identified potential impact to be significant, they may seek to determine if the environmental data and technical information properly assess this impact. Our companion "Technical Manual" may offer the reviewer some assistance in this task. If the reviewers of EIS's feel that the potential impact is not significant, they may either ignore the environmental data and technical material presented in the EIS or criticize the impact statement for wasted effort in collecting and analyzing irrelevant data. If the potential impact seems significant, but the reviewer does not feel capable of assessing the technical information, they may:

1) move on to another topic,

2) affirm the significance of the potential impact but avoid evaluation of the impact on the environment, or

3) request a qualified person to review the technical material.

1.3.3. Assessing the Adequacy of the Questions Addressed

One of the most difficult tasks of a reviewer is to determine if the correct environmental questions have been asked in an EIS. This is a very important task because the adequacy of the environmental data and technical information depends upon the relevancy of the questions the information seeks to address. Reviewers will have to prepare themselves for this task. We suggest the following approach:

1. Identify a number of possible and significant impacts. Those who review many impact statements should maintain a reference notebook which contains brief descriptions of possible impacts. These commonly encountered impacts may be treated as starting hypotheses in the EIS review. A number of these impacts are identified within this manual.

2. Identify the most likely conditions for the impact to occur. The possible impacts may be related to certain types of conditions. These "most likely to occur" conditions need to be compared to the conditions of the proposed project described by the EIS under review. This comparison may enable the reviewer to select which of the possible and significant impacts should be addressed in the EIS.

3. Identify the techniques and approaches which may be used to assess the significance and likelihood of each possible impact. There will usually be some techniques or approaches for assessing each possible impact. By knowning these (at least in a general way), EIS's may be reviewed to see if information has been collected which is relevant to the more likely possible impacts. If such information is not present, a basis exists for criticizing the EIS. If the information is there, then a review in greater depth may be appropriate.

1.3.4. Assessing the Significance of Impacts

Usually, the easiest impacts to identify as being significant are those which have a direct economic measurement. NEPA, however, specifically seeks to go beyond mere "economic and technical consideration".[6] Reviews of EIS's offer additional important and critical inputs to the decision making process by describing and identifying important impacts which may not have been considered. There are no fixed rules for identifying the significances of many impacts. The following, however, are offered as very general guidelines:.

1) An impact which is chronic (long term) may be more significant than an impact which acute (short term).
2) An impact which is widespread is more significant than a comparable impact which is contained in a small areas.
3) An impact which affects biota or habitats which are rare is more significant than an impact on something which may be ecologically common or replenishable.
4) A possible impact which is harder to correct is more significant than a comparable impact which is easier to correct.
5) A possible impact which would be difficult to identify in an early, more correctable stage is more significant than a comparable impact which could be more easily identified in a similar stage.

1.3.5. Assessing the Importance of Impacts

The following equation expresses one way of assessing the relative importance of different impacts:

$$I = P \times S$$

6. The National Environmental Policy Act (*loc. cit.*) 102(2)(B).

where: I = the relative importance of an impact, S = the significance of the impact and P = the probability (odds) of the significant impact occurring.

Very seldom are actual numbers available to "plug in" to the above equation. The informed judgement of an EIS reviewer, however, may be considered as a means to express order of magnitude importance of the concept expressed by this equation. Thus, the term, P, may be considered to be the assessment of the likelihood of occurrence (how likely is the impact), and S is an informed assessment of the significance of the impact occurrence.

The importance of this concept is this: one does not have to necessarily prove beyond a reasonable doubt (P near 1) that a significant impact will occur in order for it to be an important consideration (high value of I). If it is believed that a possible impact has less than a 50% probability of occurring, then the impact may still be a very important consideration if the value of its significance is very high. The review of impacts should not be limited to those impacts which are relatively certain to occur. Significant impacts (particularly long term impacts which often involve secondary effects) which could occur (P not equal to zero, but very low) should also be considered. Similarly, the inability through either lack of environmental data or technical information to assign values to P or to S should not be interpretted as "no impact" but, rather, as "impact unknown".

1.3.6. Broader Considerations

There are some limitations to the above approach which need to be considered. The approach assumes that the significant impacts may be identified as possibilities, yet too often unforeseen impacts often occur as a result of multiple causes. In these instances, an environmental strategy is needed which is based upon the acknowledgement that we are unable to foresee all impacts as possibilities and that some of these impacts may be very significant. Under such a strategy,[7] one should attempt to:

1) avoid large scale irreversable changes,
2) preserve variety and options,
3) monitor changes so that actions may be changed or corrected as soon as serious adverse impacts are noted, and
4) confine potential widespread environmental impacts.

1.4. ORGANIZATIONAL STRUCTURE

1.4.1. Guides Manual

This manual is divided into two major sections as directed in the CEQ Guidelines:[8] the environmental setting without the project, and probable impacts of the project. Within each one of these sections, information is presented under physical, biological and human sub-sections. References between sections are noted as GM plus the section number.

1.4.2. Technical Manual

A technical manual ("A Technical Manual for Review of Environmental Impact Statements for Dredging") may be used as a primary reference source for the "Guides Manual". The same format has been adopted as in the "Guides Manual" and detailed technical information relevant to the material in the "Guides Manual" has been presented. References to the "Technical Manual" are noted as TM plus the section number.

7. Bella, D.A. and W.S. Overton, "Environmental Planning and Ecological Possibilities," J. of Sanitary Eng. Div., ASCE, 93, SA3, 579-592, 1972.

8. The Federal Register (*loc. cit.*) Sec. 1500.8(a)(1).

1.4.3. Areas Not Covered

Certain areas of EIS's are not covered in these two manuals due to limitations of the scope of our study. These areas include:

1. identification of impacts on land use plans,
2. comparison of various alternatives,
3. identification of relationships between local short-term uses of man's enviroment and maintenance and enhancement of long-term production,
4. listing of irreversible and irretrievable commitment of resources, and
5. identification of most terrestial physical and biological impacts.

2. Important Concerns in Environmental Impact Statement Review

The review of environmental impact statements is a critical task. It represents a feedback mechanism which can provide incentives to improve the entire impact assessment process. If impact assessment is to improve decision-making processes, then the review of environmental impact statements must be both critical, thorough, and thoughtful.

The majority of this manual provides a guide to high-detail requirements for EIS's. It is believed that a high perspective view of the EIS process is also needed; the synopsis of such a view is provided in this chapter. The complete text of the arguments leading to this synopsis are provided elsewhere[1].

Two strategic concerns were identified as important for making the EIS process more successful. The first, accountability, suggests that the social system including persons who prepare and review impact statement should be structured in some ways similar to the disciplinary communities of science and technology. The second concern relates to a committment to maintain developmental diversity in natural environments. These two concerns are described, along with suggestions for implementation, in the chapter.

[1]Bella, D. A., "Accountability for the Rationale of Impact Statements", and "Fundamental Attitudes and Committments for Impact Assessment", Engineering Experiment Station, Oregon State University, Corvallis, Oregon, 1977.

2.1. ACCOUNTABILITY

2.1.1. Concern

An identifiable community of persons who prepare and review environmental impact statement does not appear to exist. As a result, individual accountability from professional peers doesn't seem to be an important incentive for doing careful and thoughtful work and for the evolution of new and inventive approaches for environmental assessment. A professional social climate should be encouraged where individuals are held accountable for their professional work and where a relevant body of knowledge evolves.

2.1.2. Suggestions

The rationale for an environment impact statement or other information used to assess a project should be clearly described. Moreover, professional authorship should be identified,. Concepts, ideas and approaches then can be discussed and reviewed by professional peers. Such discussion and review would tend to provide professional affirmation for good work while discouraging poor work. The exchange and selection of concepts, ideas, and approaches would promote an evolution of improved ways of conducting environmental impact assessments and project evaluations.

It is suggested that fundamental assumptions, basic approaches and the rationale for impact statements and other professional information used to defend, advocate or select an activity be clearly described in a written form similar to those of professional papers found within science and technology. Such professional descriptions of rationale should be clearly identified within impact statements. They should be more than summaries; they should be the basic communication form from which informed critical review can proceed. These descriptions should clearly and concisely address concerns such as "what questions did the study attempt to ask?", "what principles, concepts, and assumptions, guided the study?", "what kinds of statements resulted from the study?", and "are such statements defensible and relevant with respect to environmental decisions?". When a proposed project is defended, advocated or selected on the basis of what appears to be professional (e.g., technical, scientific, economic, ecological) information, the basis for such information should be professionally documented and available for critical review. Such documentation might not be included within an environmental impact statement, but it should nevertheless, be available. The absence of such documentation warrants strong criticism.

It is also suggested that the authorship of those responsible for the rationale of impact studies and any professional information used to defend, advocate or select a project be clearly identified as authors. Such authorship establishes the professional identity of those responsible for the content of an impact statement and other relevant documents. Peers should know who is responsible for impact statements; they should be able to identify those responsible for the information upon which decisions are justified; they should know who to direct questions to and they should know to whom credit or blame should be attached. Where authorship has not been identified, then reports should be critized and the names of those professionals who are responsible for different sections, statements, and information, particularly, controversial information which may be critical to decisions should be sought out. As an example, if a statement for a project claims substantial "Wildlife enhancement benefits", ask for the names of the wildlife biologist(s) and economist(s) who are professionally responsible for such benefit assessments.

Important and controversial impact assessments and other documents should be selected for technical review and discussion by the authors at professional meetings which are not dominated by particular institutions or interest. Professional review of one's work away from employing institutions tends to expose the quality of work and associate the author's reputation with that work. A number of existing workshops and seminar programs might be used for this purpose. As an example, each state has a water resources research institute at one of its land grant universities. These institutes regularly provide interdisciplinary seminar series on water resource topics. Discussion of impact assessments by authors would be an appropriate topic for such seminars.

Post-impact studies by qualified independent groups should be undertaken. Often environmental impacts are difficult to observe. The same mistakes can be made over and over again. Post-impact studies would tend to identify and hopefully correct past mistakes. They also would tend to maintain accountability for past work. Post-impact studies should identify and examine the professional rationale which was used to select a particular project and the social, institutional, and political influences upon the project.

2.2. DEVELOPMENTAL DIVERSITY

2.2.1. Concern

A long-term sensitivity towards protecting developmental diversity seems to be lacking in the environmental assessment of many development projects, especially large-scale civil works. Protecting developmental diversity involves directing developmental efforts into certain areas, while maintaining other areas in a relatively undeveloped state. NEPA calls for protection of diversity and for environmental strategies which are directed to NEPA's broader goals of supporting the diversity approach. Under this approach, the protection of relatively undeveloped estuarine systems, subsystems, and habitats should be given a high priority.

2.2.2. Suggestions

The areas which the project will influence (directly and indirectly) should be identified. The nature of the review should depend upon whether the areas influenced by the project are relatively developed or undeveloped. This approach suggests that universal standards may not always be appropriate or desirable. General standards for review are provided below:

Projects Influencing Relatively Developed Areas:

1) The project should support estuarine dependent activities.
2) The project should contribute to the efficient use of the developed estuarine areas and in so doing, discourage the sprawl of activities into relatively undeveloped areas.
3) The project should not encourage the sprawl of secondary impacts or the utilization of limited estuarine areas for non-estuarine dependent uses.

4) Environmental constraints should be directed to minimizing and confining long term impacts. If environmental standards are set too high for short term impacts (e.g. low turbidity and high dissolved oxygen requirements during the dredging operations), the long term environmental consequences may be negative. As an example, high dissolved oxygen requirements for dredging operations within a developed estuarine region might eventually encourage development of less developed regions where standards can be more easily met.

Projects Influencing Relatively Undeveloped Areas:

1) The project assessment should show overwhelming reasons why an undeveloped area should be developed.
2) If 1 is met, the project should be done in such a way as to minimize or eliminate unjustifiable secondary impacts, particularly those impacts which extend into relatively undeveloped areas.
3) If 1 is met, it should be clearly demonstrated that the project goals cannot be met within more developed regions.
4) In general, projects within relatively undeveloped estuarine areas should be discouraged. Agencies whose projects tend to "nibble away" undeveloped areas should be criticized.

3. Environmental Setting Without the Project

3.1. PHYSICAL

3.1.1. Environmental Quality

3.1.1.1. Water Quality

The water quality section should give a general description of those chemical and physical characteristics of the water column which could be significantly altered by the dredging project or provide needed information for the assessment of other impacts. This description should extend throughout the entire estuarine system and to any potential ocean disposal sites to allow for comparison of alternatives. Since water quality can directly impact the biota, special efforts should be given to describing parameters to which the biota are especially sensitive.

Salinity and Temperature. Typical salinity distributions (summer and winter) should be shown for the entire estuarine system since salinity can be used to define the mixing characteristics in the estuary (GM 3.1.2.1.). Areas with steep spatial gradients of salinity (representative of little mixing) will be especially sensitive to physical alterations from dredging and can be identified from salinity contour maps. Knowledge of the salinity and temperature regimes at the disposal and removal sites will provide information about the type of biological communities that can be expected and is necessary to determine saturated dissolved oxygen concentrations (TM 3.1.1.).

Suspended Solids and Turbidity. The most obvious impact of dredging removal or disposal is a temporary increase in turbidity and suspended solids. For this reason, seasonal background suspended solids measurements in the water column should be shown at both the removal and disposal sites. Environments which have constant low levels of suspended solids during periods of the year probably have biological populations present during those periods which are sensitive to suspended solids increases from dredging.

Nutrients. Evidence of eutrophic conditions in the form of reoccurring phytoplankton blooms in the estuarine system should be presented since dredging can result in significant ammonia discharges. Algal growth in estuarine systems is limited by nitrogen and only rarely by phosphorus. Therefore, only typical inorganic nitrogen concentrations in the water column need be given as an indicator of eutrophic conditions. Inorganic nitrogen concentrations above 0.1 mg N/ℓ can be considered to offer the potential for algal growth. Typical background inorganic nitrogen (ammonia and nitrate) values should be measured for the dilution water used in the elutriate test (TM 3.1.4.).

Dissolved Oxygen. Since dredging can directly influence the dissolved oxygen regime (TM 3.1.3.), dissolved oxygen data should be included. These data should be collected synoptically with the temperature and salinity data at the disposal and removal sites.

Heavy Metals. A table of past and present known heavy metal inputs to the estuary (riverine and point sources) should be shown. Concentrations, particulate (filtered solids) and soluble, should be listed where known. Evidence to date from both field and laboratory studies indicates that dredging has very little effect on soluble heavy metals concentrations in the water column. In addition, elutriate tests have shown little correlation between increases in heavy metals concentrations in the water column and total concentrations of these metals in the sediments (TM 3.1.4.). Nevertheless, potentially significant increases in heavy metals have been found in isolated tests (TM 3.1.4.). Thus, heavy metals concentrations in the water column should be provided for the elutriate test where sources have been identified. In general, when metal inputs are present, mercury, copper, lead, chromium, zinc, arsenic, cadmium, nickel and any other metals from known sources should be measured.

Toxic Hydrocarbons. Studies to date have shown that toxic hydrocarbons are not significantly solubilized in either dredging removal or disposal operations (TM 3.1.3.). As such, background data for these compounds in the water column are not necessary except in the dilution water if toxic organic compound release is to be evaluated in the elutriate test.

Measurements Not Required. It is generally not necessary to measure the following parameters in the water column unless there is evidence that specific or unique conditions exist in the estuary (see TM 3.1.3.). These parameters are: 1) pH; 2) BOD, COD, TOC; 3) total phosphorus; and 4) oil and grease.

Concerns. Are adequate salinity and/or temperature data provided to enable saturated dissolved oxygen calculations and to ascertain the mixing characteristics of the estuary throughout the year?

Are seasonal turbidity and/or suspended solids levels provided to allow comparism to those levels expected during the dredging operation?

Are algal blooms a reoccurring water quality problem and, if present, are inorganic nitrogen concentrations listed?

Are seasonal dissolved oxygen concentrations reported?

Are heavy metals identified which could be present from known or suspected sources?

For those heavy metals which may be present, are the background water column concentrations included?

3.1.1.2. Sediment Quality

The sediment quality section should give a general description of those chemical constituents which could be significantly altered by the dredging projects and provide chemical data which can be used for assessment of other impacts. Sediment quality may be used to describe the ability of a sediment to support a diverse biological community. The sediment quality, which will be primarily determined by the chemical constituents, will reflect the history of geologic sources and pollutant discharge to the dredging site. For example, estuarine sediments are known to be major sinks for heavy metals and toxic hydrocarbons.

While bulk analysis is not useful for predicting water column effects, certain bulk analyses are necessary to ascertain other impacts. For example, total sediment chemical analysis for several parameters should be done where the chemical similarity between dredge material and the disposal site are unknown. Many of the adverse impacts of open-water disposal probably can be avoided by matching the physical and chemical properties of the dredge material with those present at the open-water disposal site. The most useful chemical parameters would be volatile solids, ammonia, total sulfides and hydrogen sulfide since these, as well as physical parameters, will indicate the nature of the biological community present. Many other parameters for bulk analysis including various metals and pesticides have been suggested for estimates of sediment compatability between the removal and disposal sites; these parameters may be useful in specific instances (TM 3.1.4.).

Free sulfides are known for their extreme toxicity to estuarine biota. The potential for formation of free sulfides may be estimated by knowing the reduced sulfide capacity (RSC) (TM 3.2.4.). As the total sulfide concentration approaches the RSC (within 100 mg S/Kg), free sulfides will accumulate in the interstitial waters. The comparison of total sulfide and reduced sulfide capacity data for the dredge spoil can be used to estimate whether free sulfides are likely to occur in the sediment. If free sulfides are observed qualitatively (H_2S odors), a reduced sulfide capacity test is not required.

Concerns

Has chemical compatability been assessed for the dredge site and potential open water disposal areas?

Has the presence of free sulfides been detected?

Has it been shown whether the sediment has potential for free sulfide formation?

3.1.2. Hydraulic and Hydrological

3.1.2.1. Circulation and Mass Transport

Detailed descriptions are required of both the near field region (disposal and removal sites) and the far field region (total estuarine system). These detailed descriptions should include the following:

1) the cross-sectional profile and plan view geometries scaled drawings,
2) stratification of the water column,
3) tidal motions,
4) land drainage, and
5) surface gravity waves.

In situations where these descriptive parameters are modulated by seasonal factors, the detailed descriptions should incorporate this seasonal dependency.

Geometry. The required cross-sectional profile and plan view drawings must be correctly scaled and accurately dimensioned. Cross-sectional profile transects are usually distorted in the vertical scale as the horizontal scale is usually much larger than the vertical scale. These dimensions are required to describe flow rates and circulation patterns. (TM 2. Hydrodynamics and Circulation)

(Near Field). A cross-section profile drawing must be prepared for the terminal ends of the near field regions for both removal and disposal sites and for at least one representative intermediate location if the dredging and/or removal site(s) are extensive in plan view. A cross-section profile drawing for an intermediate location should also be prepared whenever significant bathymetric changes occurs. Seasonal changes in bathymetry such as extreme tidal stages or migrating shoals should also be indicated on the cross-section profile drawing.

(Far Field). An accurately scaled plan view of the estuary system and cross-section profile drawings of the inlets or mouths of the estuary (if not already included in the Near Field sites) and of each principal tributary are required. Additional cross-sectional profiles should be included where unusual bathymetric changes exist which could significantly influence the circulation processes. Examples of such unusual bathymetric changes include migrating or stationary shoals, sills, land points or other boundary constrictions to the flow patterns. Seasonal influences on these boundary constrictions must also be indicated.

Stratification. Measurements of salinity values are required for the estuary classification method developed by Hansen and Rattray (TM 2.4.1.). Measurements of salinity should be made at the same locations as those described by the cross-section elevation drawings and should be simultaneously made with all other measurements and samples whenever possible. Two types of average salinity values are required in order to classify the estuary: values at both the surface and the bottom averaged over a tide cycle and a value averaged over both depth and a tidal cycle. Seasonal salinity values are required for most estuaries.

(Near Field). The required salinity measurements should be made at the terminal ends of the near field region and at the intermediate locations described by the cross-sectional profile drawings.

(Far Field). The required salinity measurements should be made at the inlets or mouths of the estuary, at the mouths of all principal tributaries, and at those shoaling locations which are not covered by the near field.

Tidal Motion. A description of the tidal motions must include measurements of both the free surface elevation and the magnitude and directions of the water velocity over at least one tidal period. Records from both neap and spring tidal ranges should be included. These records should be made at the same locations as those described by the cross-sectional drawings and should be made simultaneously with all other measurements whenever possible. When it is not practical to measure the tidal velocity at several vertical and horizontal locations at any one cross-sectional site, the tidal velocity should be measured in the principal flow channel at both 20% and 80% of the average depth above the bottom or at 37% of the average depth above the bottom. If the flood and ebb flow channels are significantly different, measurements should be made at both locations. From the measurements of the velocity over a tide cycle, a vector summation of the mean current should be shown (TM 2.3.3.). The amplitude of the free surface elevation should be determined from the tide height measurements over a tide cycle. The phase differences between the free surface fluctuation and the tidal velocity are required at each recording site (TM 2.5).

(Near Field). Tidal motion records should be recorded at the terminal ends described by the cross-sectional profile drawings.

(Far Field). Tidal motion records should be recorded at the inlets or mouths of the estuary and at the mouths of all principal tributaries at the locations described by cross-sectional profile drawings.

Land Drainage. Average and peak discharge rates, if large, are required on at least a seasonal basis. These discharge rates are frequently expressed in probabalistic terms (e.g., 10 year storm). Drainage data are especially important for developed areas where paving and other surfacing of natural drainage patterns significantly increase drainage runoff.

(Near Field). Discharge rates are generally not required unless a principal tributary or principal drainage pattern discharges directly into the near field site.

(Far Field). Discharge rates are usually added to or included in the tributary flow rates.

Surface Gravity Waves. Surface gravity waves are a primary force in the suspension and erosion of sediments, especially in shallow tidal flat areas. These waves may either propagate into the estuary through the estuary inlets as swell from the ocean or they may be locally generated from winds. In addition, ship waves may be generated from local ship traffic and induce severe erosion. Both the locally generated wind waves and the swell are, in general, random processes and are very difficult to measure in sufficient detail to accurately describe their setting without incurring a great expense. As a consequence, these data should be empirically generated from wind statistics. Sea swell data can usually be obtained from historical records. Wind wave data should be estimated from recorded wind velocity measurements (TM 2.6). Ship wave data should be calculated from estimated ship size, frequency and velocity (TM 2.6).

(Near Field). Swell and ship wave data should be emphasized at the removal site near an inlet, while wind and ship wave data tend to dominate the processes at a removal site located up in the estuary. Similarly, swell and ship wave data are important for a disposal site up in the estuary from an inlet.

(Far Field). Emphasis should be placed on swell and ship wave data near inlets; while sea and ship wave data should be emphasized up in the estuary away from inlets.

Concerns. Are accurately scaled plan view and cross-sectional drawings of both the near field and the far field provided?

Has adequate salinity data been included to allow the estuary to be classified according to the salinity classification system of Hansen and Rattray (TM 2.4.1.)?

Are tidal amplitude and current measurements provided for the points where cross-sectional maps are shown?

Are land drainage discharge measurements provided?

Are data on frequency and height of swell, wind and ship waves provided?

Table 3.1.1. Summary of Background Data to Describe Circulation and Mass Transport.

PARAMETER	NEAR FIELD	FAR FIELD
Geometry		
Accurately scaled plan view and	Required	Required
Accurately scaled cross-section profiles	At terminal ends and at significant bathymetric features	At inlets or at mouths of estuary and at all principal tributaries and significant bathymetric features
Stratification (TM 2.4.1.)		
Tidally averaged values of salinity at surface and bottom and	At terminal ends	At inlets or at mouths of estuary and all principal tributaries and significant shoals
Tidally and depth averaged values of salinity		
Tidal Motions		
Tidal amplitude over several periods of spring and neap tides	Terminal ends	At inlets or at mouths of estuary
Current velocities for both flood and ebb flow channels	Terminal ends	At inlets or at mouths of estuary and all principal tributaries
Land Drainage		
Peak and average seasonal discharge rates	Required only if discharge is directly into site	Usually added to principal tributary flow rates
Surface Gravity Waves		
Down estuary (near inlets)	Swell and ship waves	Swell and ship waves
Up estuary (inland from inlets)	Wind and ship waves	Wind and ship waves

Note: All measurements should be made simultaneously with all other measurements required by other biological and physical concerns whenever possible and at the cross section profile sites noted under Geometry.

3.1.2.2. Groundwater

Wetlands adjacent to estuaries can be important sources of freshwater for groundwater aquifiers. Many estuaries, especially of the drowned plain type, have geologic formations which favor the existence of potential aquifers. These adjacent wetlands also serve as possible sites for land disposal of dredge material.

The groundwater section should describe the present use of aquifiers for water sources and the association of these aquifiers with adjacent wetlands. A geologic log and location map of present wells which draw water from the aquifier should be presented to describe the size of the aquifier and the permeability of the overlying materials. Where existing, U.S. Geological Survey surficial maps should be included. The placement of potential dredge disposal areas should be shown in relation to the well logs.

Concerns. Are quantities and the quality of ground water usage specified?

Are the logs and location of present wells specified in adequate detail to show the extent of the aquifier and the nature of the overlying strata?

Are the placements of land dredge material disposal areas shown in relation to the location of aquifiers?

Are the potential situations for contamination of aquifiers from the land dredge material disposal sites identified?

3.1.3. Geological

The geological setting has important implications for sediment transport and biota distribution (TM 4.1.3.). Evaluation of meaningful geological parameters may, for the most part, be limited to the confines of removal and disposal sites unless significant erosion and/or sedimentation in adjacent areas is possible. The distribution of sample stations should be selected to ascertain horizontal and vertical gradients within the site(s) (TM 4.2.3.). A description of the setting should include:

1) identification of sensitive landforms,
2) sediment textural analysis,
3) distribution of solid and liquid fractions, and
4) composition of solids constituents.

3.1.3.1. Identification of Sensitive Landforms

Dredging of navigation channels may create preferred flow channels and change circulation patterns in the estuary and near the mouth (TM 4.5.1.). Sedimentary escarpments and spits may be exposed to increased hydraulic erosion from local high velocities or ship wakes. Jetties, training walls, and other hydraulic structures constructed in conjunction with the project may shelter small embayments of sloughs and cause increased sedimentation (TM 4.1.2.). Potentially sensitive landforms such as these should be identified on charts so that their response to modified circulation patterns can be assessed relative to historical trends.

3.1.3.2. Sediment Textural Analysis

Sediment grain-size distribution has been shown to impose a limiting condition on deposit feeding and filter feeding biota (TM 4.1.3.). Grain-size information is an essential input to the analysis of erosion and deposition of coarse grain sediments (TM 4.4.2.). Textural analysis should include both the coarse and fine fractions in the removal and disposal sites. The compatibility of dredge spoils with in-situ sediments at the aquatic disposal sites must be established. Also, the type of material to be exposed at project depth at the dredge site should be determined. If sensitive landforms have been identified, the texture of these sedimentary deposits should also be evaluated.

3.1.3.3. Distribution of Solid and Liquid Fractions

Sediment water content is an important quantity for burrowing biota (TM 4.1.3.). Water content and void ratio are also essential inputs to the evaluation of erosion of fine-grained, cohesive sediments (TM 4.4.3.). The water content must be compared to the liquid limit and plastic limit for cohesive sediments so that resistance to erosion can be evaluated. The latter quantities are important only for cohesive sediments, and when combined with void ratio and grain size allow one to utilize most existing models for the prediction of fine-grained sediment transport. These properties are particularly important at the removal site, and the disturbed water content of the settled spoils should be compared to existing conditions at the aquatic disposal sites. Certain animals are known to consolidate and strengthen sediments while others disperse and weaken sediments (TM 4.1.4.). Consequently, the biological setting should be coordinated to estimate interactive animal-sediment relationships.

3.1.3.4. Composition of Solid Constituents

Animal abundance and activity increase measurably with increasing organics in the sediment (TM 4.1.3.). Organics are frequently of low density and therefore contribute to turbidity levels associated with suspended sediments. The organics level can be quantified in terms of volatile solids and should be evaluated at both the removal and disposal sites. Also, armoring of surface sediments by macroscale shell fragments has been observed in areas of high shell fish productivity (TM 4.5.2.). Identification of relic or active biological surface armoring should be completed in those areas where natural armoring may be disturbed.

3.1.3.5. Concerns

Have adjacent landforms or hydrographic features which may be eroded or experience sedimentation due to activities associated with the project been identified?

Are the particle-size distributions and water contents listed for the dredge material and for the sediment at the disposal site?

If the dredge material is primarily composed of fines, what is the water content compared to the liquid and plastic limit?

Are the organic content of the dredged material and the sediment at the disposal site determined?

Have large variations of physical properties with depth been identified?

Are the physical properties of the dredged materials compared to in-situ materials at the spoil site?

Is the stability of the sediments at the disposal and removal sites strongly influenced by armoring from biological debris (i.e. shells)?

3.2. BIOLOGICAL

The environmental setting should contain sufficient information to allow for the determination of possible impacts to biological populations. Since the biota tend to integrate all elements of the environment, physical and chemical measurements should relate to the biology. The biological processes are very complex and have multi-dimensional interactions with physical, chemical and other biological processes.

The environmental setting, to provide a satisfactory description of the background biological conditions, should address four important considerations concerning the fauna and flora present:

1) identification of the important species (ecological and commercial),
2) determination of the quantity and distribution of the biota,
3) identification of important ecological interactions, and
4) description of important habitats.

These descriptions should be accomplished at the removal site, the disposal site, and any other sites considered in the various alternatives. In instances where "in kind" mitigation seems likely to replace a lost resource, the above information should be provided for each area or habitat which may potentially be used in the mitigation process (TM 5.12).

3.2.1. Species Identification

A description of the biota present requires judgement as to which data will provide the most useful information. A complete species list may not be effective for assessing impacts, especially in relation to its cost of preparation (TM 5.4). However, the sampling and/or analysis should be complete enough to determine the presence of species known to be commercially important, rare, endangered, or important links in food webs (TM 5.5, 5.8, 5.9, 5.0) In addition, the presence of species that have strict habitat requirements which could be altered by dredging should be determined, along with the presence of known indicator species (TM 5.3). A rationale for the inclusion of certain species and exclusion of others in the species list should be given (TM 5.4). Taxonomic identification of animals present should be completed to the species levels to enable description of potential impacts (TM 5.4).

3.2.2. Determination of Quantity and Distribution of Biota

The measurement of the quantity of the biota present gives information on significance and dominance of each species. This can be expressed as abundance ($\#/m^2$, $\#/m\ell$) or biomass (g/m^2 wet or dry weight, or standing crop), or productivity. In addition, certain statistical measurements such as diversity (species richness and equilibility) can provide useful information (TM 5.3). Spatial distributions should be shown on maps to illustrate uniform presence or "patchiness". Sampling programs should be designed to generate these data, if not available, and should include all the important habitats in the estuary.

3.2.3. Identification of Important Interactions

The physical, chemical and biological interactions are most difficult to describe, but are very important. Many potential chemical and physical changes can be associated with a dredging project and these changes will result in direct or indirect impacts on the biota. One must have some knowledge of the operation of the estuarine system before any predictions can be made concerning the impacts of a project. For the biological background data, known predator-prey interactions must be included. Information and stability or resiliency of existing communities, the productivity of habitats, species tolerance to pollution, seasonal variations, and important nutrient cycles should be included (TM 5.5, 5.6, 5.7, 5.11, 5.13).

3.2.4. Important Habitats

Important habitats near the dredging removal and disposal sites need to be identified. If the project is extensive, habitat maps should be shown for the entire estuary. The habitat maps should be specific enough to show locations of all dominant species. These maps can be prepared from visual observation and do not need to be quantitative. Narratives describing the ecological interactions between habitats should be provided (TM 5.2.).

3.2.5. Concerns

Is a rationale given for selection of the species included in the species list?

Are commercially or ecologically important, rare, endangered, and indicator species identified?

Are the quantity of dominant species provided?

Are important physical-chemical interactions with the biota noted?

Are important interspecies relationships listed?

Are habitats which are likely to be impacted identified and located on maps?

3.3. HUMAN

3.3.1. Economics

3.3.1.1. The Scope of the Assessment Process

Baseline economic information is necessary for the assessment of project impacts. The appropriate type and quantity of information depends on which project impacts are to be measured, the more comprehensive the impact assessment objectives, the more comprehensive the necessary inventory of economic information. The following list is appropriate to a fairly comprehensive assessment and may exceed the requirements for any particular project at any particular point in time. If this is the case, certain categories of information can be excluded from the collected baseline data. Over time requirements are expected to change, consequently the list has not been restricted to current institutional requirements. In addition, social impacts must be recognized as being derived from the economic impacts. Hence, regional economic impacts must be ascertained in order to facilitate the social impact assessment even if they are not required for their own sake. To understand the interrelationships within a comprehensive assessment process and the place of the assessment process within the project decision process, the reader is urged to consult other appropriate sections of the study (see TM 6. Economics).

The relevant economic impacts of dredging projects must be assessed from the point of view of the nation, the directly impacted area, and possible other subareas in which the economic effects are identifiable and large.

3.3.1.2. National Economy

The economic setting of the national economy without the project can be ignored. Published information is widely available.

3.3.1.3. Economy of the Directly Impacted Region

For the directly impacted area, the selection of baseline economic data should include measures of all pertinent aspects of the local economy which may be impacted by a dredging project.

Production. Historical data measuring economic activity in the region should be assembled for a sufficient number of years to indicate secular trends. It should be collected and reported by industrial classifications, the more detailed the classifications the better. A number of measures can be utilized. In order of preference they are value added, employment, sales and physical units. Either or both of the latter two are not sufficient by themselves.

Personal Income and Per Capita Personal Income. Personal income and per capita personal income data should be assembled for a sufficient number of years to indicate secular trends.

Public Infrastructure Capacities and Percentages of Utilization. Data should be assembled on the capacities and percentages of utilization for all elements in the area's infrastructure: primary and secondary schools and regional colleges, water supply and sewage collection and treatment systems, police and fire control facilities, solid waste disposal facilities, recreational facilities, hospitals, libraries and other local government facilities.

Housing Capacity and Percentages of Utilization. Information on the housing stock and percentage of utilization should be included.

Residential Industries. Data should be assembled on the availability, capacities, and percentage of utilization for various branches of the retail and wholesale trade and service industries. These are economic activities which are oriented to the local population. Of particular importance are professional specialists in the health care, legal, financial and other service fields; restuarants, threatres, and other amenity producing activities; speciality stores, local newspapers, radio and television stations and other media enterprises, etc.

Transportation. Data should be assembled on the availability, capacities and percentages of utilization for both internal transportation services and facilities including street and local highway systems, and connective transportation services and facilities which give access to external places. Commercial, local transit and interregional air, bus, rail and pipeline facilities and service schedules and interregional highways are of particular importance.

Land Availability. Data should be assembled on the availability of land by class, by current zoning and by comprehensive and/or long range plans.

Local Taxes. Data should be assembled on the property tax base and mill rates and other local tax revenue sources and rates.

Energy. Data should be assembled on the availability, capacities and percentages of utilization for the various energy sources utilized in the area.

3.3.1.4. Concerns

Are the baseline data presented in a manner which facilitates its use in the economic impact assessment and project decision process?

Do the baseline data pertain to the relevant area rather than a more comprehensive area such as a county or standard metropolitan statistical area for which published is more readily available?

Are the economic data current?

3.3.2. Social

The environmental setting section should provide a description of a variety of social characteristics of both the immediate, local area likely to be impacted and any other more distant areas which are also likely to undergo significant social change as a result of the project. Several factors should be included for the description of the sociological (or social) setting to be adequate to assess the various impacts.

3.3.2.1. Range of Social Variables Used to Describe Setting

Because of the large social differences in the communities and regions likely to be impacted, it is difficult to specify a small number of variables which should always be included. Instead, relevant variables for the background description should be selected from some comprehensive listing of potential variables. A comprehensive list should include several major categories such as social institutions, population characteristics, "life style", cohesion and conflict, etc. (TM 7.2). Therefore, since every aspect of social life cannot be reasonably described, the selection of variables is extremely important. The rationale used for inclusion of some social factors and the exclusion of others should be briefly described. In addition, it is especially important that the description of the "social" setting should not be limited to only economic terms, such as employment, income, and land values. Too often descriptions of the setting focus only on the economic institution, and fail to include the other social institutions (education, political system, family and religion) (TM 7.2.1.).

3.3.2.2. Description of Social Change

Whereever possible, information should include reference to both present <u>and past</u> social conditions. This is important as one basis for making projections about the future, and in turn, for attempting to estimate how the future would be different because of the project, or project alternatives. Thus, describing the population with 1970 census information is meaningless without comparable data from the 1960 census. Reference to current water-related recreational opportunities is incomplete without mention of how they compare with five or ten years ago.

3.3.2.3. Multiple Zones of Influence and Target Groups

It is usually difficult to identify the range of areas (communities, regions, neighborhoods) which are likely to be impacted. Ideally, social impacts should be identified in terms of their differential impacts on many "layers" of society (individual, group, neighborhood, community, region, and nation). In reality, identification of potentially impacted areas ("zones of influence") involves two, somewhat contradictory, considerations. The first is the obvious fact that the areas which are closest to the project (geographically, spatially) are those generally likely to undergo the major impact. The second is that the zone of influence should also include those areas, or target groups, who may be geographically dispersed or removed from the primary zone of influence.

While there is no automatic guide to which or how many such zones of influence should be mentioned. However, it is reasonable to expect that at least three distinct, but possibly overlapping, zones, should be identified. These might include the communities bordering the estuary, an area or sub-group within these communities, and an area or city located some distance from the estuary. Discussion of multiple zones of influence does not require that the same level of detail is necessary for all zones. Failure to focus on more than one or two zones of influence usually indicates an over-simplified view of impacted areas, and omission of a major target group (typically those not living in the impacted community).

3.3.2.4. Reflection of "What Life is Like"

The description of the local social setting should be sufficiently comprehensive to give some "feel" or "picture" of what life is like in the community or communities in the immediate vicinity of the project. This is important because many readers of the Environmental Impact Statement will not be local residents. Further, even local people may gain an understanding of the general project impact from an effort to summarize what is important, unique, or special about their community. This part of the setting will probably rely on both quantitative and qualitative social data (TM 7.3), summarized in a fashion which gives some of the "flavor" of the local community. For example, is the community a "port town?" Do activities fluctuate with maritime-oriented activities (fishing season, arrival of ships, loading)? Is the port or harbor system a dominant feature or theme in the community? Local readers should be able to say "yes, that pretty much sums up what our town is like."

3.3.2.5. Diversity of Social Data Sources

The description should not rely on only one type of social data (TM 7.3). "Types" of social data can be defined in terms of the extent to which they are expressed in numbers (quantitative vs. qualitative), and on the basis of how the information was collected (analysis of written documents, observation of social situations, summarized from government statistics, social surveys or public opinion polls). Use of several different types of social data is particularly important in providing an adequate, general description of the social setting (TM 7.4.1.).

3.3.2.6. Concerns

Is the rationale for the selection of social variables described?

Will the selected social variables include social factors such as social institutions, population trends, sources of cohesion and conflict, cultural themes or values, and major lifestyles?

Is an overview of past and present maritime- or port-oriented social features of the community included?

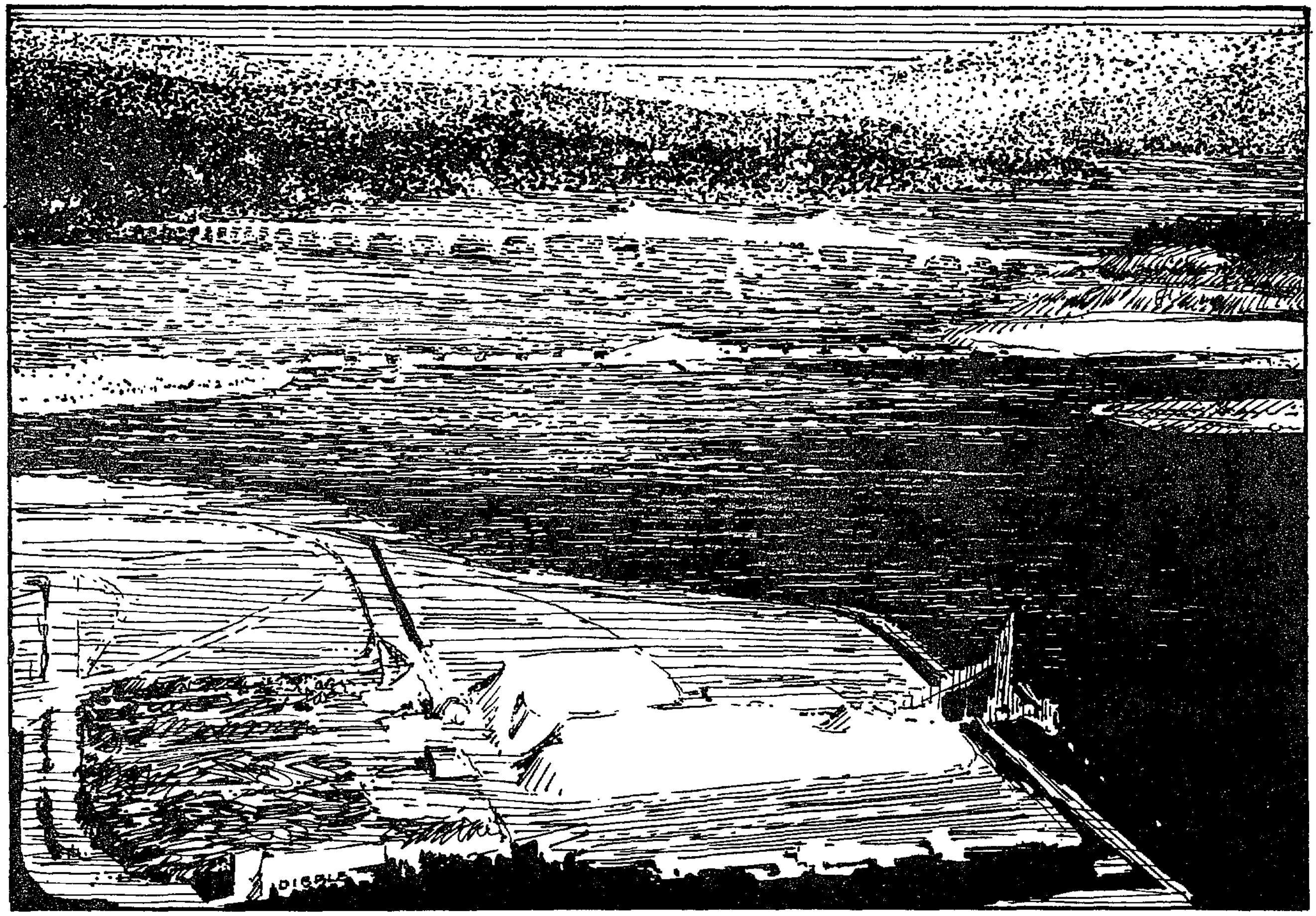
Is the time period covered by most social data long enough to provide an understanding of those trends which might be changed because of the dredging project?

Are at least three different zones of influence described? Are inland target groups ignored? Does the description imply that social impacts will occur only in the community adjacent to the project? Are data provided on different groups within the community or area, and, if so, are these different groups identified in terms of their linkage to maritime or port activities?

Is some sense or feeling of what daily life is like in the impacted communities or among the most impacted groups included?

Is information on how the present condition of the estuary, channel, jetty, or harbor fits into community life presented?

Does the information reflect an effort to obtain a variety of perspectives on community characteristics and problems and a balance of quantitative and qualitative social data?



4. Probable Impacts

Impacts on the environment are defined to be "changes or conversions of environmental elements which result directly or indirectly" from the dredging project.[1] Impacts should be identified, quantified whenever possible, and projected throughout the estimated duration of the dredging project. When quantitative descriptions are not possible, qualitative values of the impacts must be provided along with the assumptions and criteria used to determine these estimates. Impacts which have high negative or positive consequences, even if coupled with a low probability of occurence, should be carefully addressed. The cumulative impact of many incremental alterations should be projected, especially in relation to maintaining developmental diversity (GM 2.2).

1. ER 1105-2-507, para. 4.f(1), p. C-4.

4.1. PHYSICAL IMPACTS

4.1.1. Environmental Quality

4.1.1.1. Water Quality

Impacts to the water column as a result of dredging and disposal operations are evaluated by two considerations: 1) the change in the relative or absolute value of water quality parameters, and 2) potential acute (short term) and chronic (long term) effects of that parameter on the estuarine ecology.

The first consideration in impact evaluation derives directly from information on water quality parameters contained in the Environmental Setting Without the Project. Relative or absolute changes may be measured directly in the field, predicted from laboratory tests, predicted from past experience, or a combination of the above. As a minimum, the elutriate test should be performed to determine potential increases in soluble chemical parameters (TM 3.1.4.). The elutriate test data then may be coupled with a dispersion model (TM 2. Hydrodynamics and Circulation Impacts) to predict dilution and the resultant concentration increase at the disposal site.

The second consideration in impact evaluation requires a knowledge of the acute and chronic effects of various contaminants on the estuarine ecosystem. Acute biological effects of most parameters can be estimated from the results of short-term laboratory toxicity tests (TM 3.3). Chronic effects from long term, low level exposure to contaminant are largely unknown. Long term bioassays may be used to estimate some of these chronic effects (TM 3.3).

Salinity. Potential salinity impacts (acute or chronic) should be estimated from the predicted alteration of the estuarine circulation caused by the dredging project (GM 4.1.2.1.). Effects will be acute if immediate large changes in salinity result from the dredging or disposal operation. Organisms thus adapted to a particular salinity may be adversely affected. Chronic effects could result from long-term alterations of sediment transport which, through shoaling, can change circulation patterns and salinity profiles. Chronic salinity impacts may result in adaptation of different species of biota.

Temperature. Temperature changes can result from alteration of circulation patterns. However, the changes would be expected to be very small except in extreme cases of substantially altered mixing characteristics. As such, analysis of impacts from altered temperature regimes are generally not necessary.

Turbidity and Suspended Solids. Turbidity and suspended solids (hereafter referred to collectively as suspended solids) impacts may be both acute and chronic in the water column. Acute suspended solids increases are typically present at the removal and disposal sites with the duration depending on the length of the dredging operation. Chronic impacts from suspended solids may be caused by one or more of the following effects. Changes in hydrodynamic flow patterns may increase resuspension of bottom sediments. Redistribution of fine materials (clays and organics) by dredging may lead to easier suspension with subsequent higher suspended solids in the water column and "fluff" formation at the sediment-water interface. Ship traffic in dredge channels may result in continuous resuspension of fine materials from both wave action and anchor dragging.

At disposal sites, acute impacts from suspended solids depend on the type of site and method of disposal, but are generally greater than at the removal site. Concentrations of several grams/liter of suspended solids are common during disposal operations, although the effect is of short duration (TM 3.1.3.). Acute effects include the inhibition of respiration of biota and high impairment of light penetration. Chronic effects include some impairment of light penetration from resuspended sediments and long-term toxicity and bioconcentration from ingestion of adsorbed contaminants on suspended clay and organic particles.

Acute suspended solids impacts at the removal and disposal site should be estimated by listing reported suspended solids levels from under similar dredging and dredge disposal conditions (TM 3.1.3.). These should be compared to seasonal background concentrations. Any known pelagic species with critical life stages (migration, spawning, etc.) that could be affected by suspended solids should be noted. Chronic impacts should be listed with a brief narrative concerning the probability of their occurance under the site specific conditions.

Nutrients. In estuaries, increased eutrophication may result from increases in the concentration of inorganic nitrogen forms since nitrogen is usually the limiting nutrient for algal growth. Manifestations of eutrophication, such as algal blooms and increased turbidity and sedimentation rates, are undesirable for most potential uses of the estuary. Principle constituents of inorganic nitrogen include the ammonium and nitrate ions. Ammonia may be derived from external sources such as influent fresh water or precipitation. Within the estuary, ammonia largely results from bacterial metabolism of organic matter in the water column and sediments. Nitrate impacts to the estuary can come from external sources or from the bacterially-mediated oxidation of ammonia. Ammonia levels of above 0.1 mg/ℓ as N can be considered to have the potential for eutrophication problems (TM 3.1.2.).

Ammonia toxicity may result from acute increases of ammonia during dredging. Ammonia may be toxic in the range of 0.2 to 2 mg/ℓ to some aquatic biota (TM 3.1.2.). The elutriate test coupled with a dispersion model should be used to estimate what ammonia concentrations will occur (TM 3.1.4.). These concentrations should then be compared to background, toxic, and algal-stimulatory concentrations. Ammonia should be the primary nutrient parameter of interest in assessing nutrient impacts unless unusual circumstances warrant consideration of other constituents.

Dissolved Oxygen. Acute depletion of dissolved oxygen during removal and disposal operations may occur for short time periods; however, only those depletions at the disposal site which are associated with large dredging projects appear to be high enough to represent a significant ecological impact. Depletion is caused by the bacterial-oxidation of soluble organics and the chemical-oxidation of reduced inorganic compounds which are released to the overlying aerobic waters when the sediments are disturbed. The oxygen uptake rate of the sediments can be determined in batch tests (TM 3.1.3.); however, the use of these data to predict oxygen depletion is extremely difficult since other factors such as dispersion, sedimentation and reaeration are also important.

Chronic oxygen depletion may become a problem at the sediment-water interface if the sediments maintain a disturbed or "fluff" condition for extended periods. This impact should be included for all areas where fine-grained sediments will be disturbed at high frequencies and where low water velocities occur.

Heavy Metals. Evidence to date indicates that heavy metals are unlikely to be released in sufficient quantities during dredging and disposal operations to cause acute toxic effects to aquatic biota. However, a few elutriate tests have shown substantial increases in the soluble concentration of manganese, cadmium, copper, lead, zinc, and nickel under aerobic conditions and manganese, iron and possibly lead and zinc under anaerobic conditions (TM 3.1.4.). Due to the ease of analysis, elutriate test data for mercury, copper, lead, chromium, zinc, arsenic, cadmium and nickel should be reported if sources of metals to the estuary are known. The diluted concentration of these metals, as indicated from the dispersion model, then should be compared to water quality criteria.

Although acute effects from heavy metals released during dredging are generally not expected, little evidence is available to document possible chronic effects of long-term, low-level exposure. Heavy metals will probably be scavenged from solution or dispersed to insignificant levels under most circumstances in the water column. However, in disposal areas which continuously receive dredged sediments over long periods, chronic toxic effects may be evidenced from solubilized heavy metals. As such, long-term bioassays with the elutriate diluted by a factor predicted by a dispersion model should be included where the dredging project is of a large magnitude or long duration (TM 5.13).

Heavy metals adsorbed on particles may also adversely affect certain aquatic biota. Limited studies have shown that although the rate of metal accumulation is slower for particulate-bound metals than for soluble forms, deposit feeding biota may show significant increases in heavy metals over long time periods (TM 3.2.2.). Thus, any potential placement of metal-laden dredge material on or near known shellfish beds should be clearly identified. Long-term biassays (TM 5.13) or selective leaching (TM 3.2.6.) should be used to evaluate toxic or cumulative (bioconcentration) impacts from adsorbed heavy metals.

Toxic Organics. Toxic organic compounds, including primarily DDT and its related compounds, and PCB's, presently are not considered to be released by dredging in adequate quantities to result in acute toxicity in the water column.

These compounds have a high tendency to become associated with particular matter and are not resolubilized. Elutriate tests under varying environmental conditions have shown no significant release of toxic organic substances from the sediments (TM 3.1.4.). As a result, acute impact assessment of the toxic organic compounds is probably not necessary. As for heavy metals, chronic toxic or cumulative effects of sediment-bound organic compounds may be evaluated in long-term bioassays.

Concerns. Have effects from large alterations in salinity profiles been identified?

Are expected suspended solids levels compared to seasonal background levels and possible impacts on indigenous biota identified?

Are expected concentrations of ammonia at the disposal site estimated and compared to background, toxic and algal-stimulatory concentrations?

If sources of heavy metals are present, are elutriate test data for mercury, copper, lead, chromium, zinc, arsenic, cadmium, nickel and other known metals provided?

If sources of heavy metals are present, are long term bioassays or selective leaching for the dredge material shown?

4.1.1.2. Sediment Quality

Dredging impacts, which are dependent upon the sediment quality, can be classified into two groups. First, various constituents can be leached from sediments upon resuspension due to dredging. The degree of resuspension is largely dependent upon the nature of the dredging project and the impacts are highly dependent on the extent of dilution. Impacts of this type are discussed in the section on water quality and are estimated from the elutriate test data.

The second group of impacts which are dependent on sediment quality are those which alter the chemical characteristics of sediments. Typically, these impacts are chronic in nature and result from continued dredging in the same area. Chronic impacts are often difficult to quantify.

Collection of Organics and Fines. Limited-channel dredging will enlarge the channel cross section at various locations primarily through deepening of the channel. From this increase in channel area, a decrease in mean velocity can be expected. This will result in a decreased capacity to carry suspended loads and a subsequent increase in deposition.

The material which redeposits in the dredged area will be dependent on the other sources and sinks of sediments in estuaries. However, the increased human development which is induced by dredging will typically result in increased discharge of both fines and organics into the estuary. These fines and organics then will tend to collect into the dredged area. The hypothesis that dredged areas represent non-equilibrium conditions with respect to sediment transport is supported by the need for continuous maintenance dredging in most dredged channels.

Thus, increased fines and organics will be expected after limited-channel, new dredging projects. These conditions will probably radically change the resident biological community over a long period of time. The high organic concentrations will result in higher rates of sulfate reduction and increased production of hydrogen sulfide. Areas which are expected to have substantially reduced tidal velocity as a result of dredging should be clearly identified.

Hydrogen Sulfide Toxicity. Hydrogen sulfide is extremely toxic to benthic animals and, as a result, its existance can significantly alter the benthic population. The generation of hydrogen sulfide typically will result from two factors which are not totally independent: high organic content or low sulfide capacity. Dredging can affect both of these factors.

High organic contents will typically be induced in limited-channel dredging projects as described in the previous section. In estuaries with large sources of particulate organics such as sewage outfalls or significant phytoplankton blooms, the organics will collect rapidly and ideal conditions for rapid sulfate reduction will result. With organic concentrations exceeding 20 percent of the dry weight, the hydrogen sulfide production will probably exceed the available sulfide capacity and result in free sulfides (H_2S,HS^-).

Potential impacts from hydrogen sulfide toxicity should be identified if the dredge material either has free sulfides present or a low reduced sulfide capacity (<100 mgS/kg)(TM 3.2.4.). These impacts which include acute toxicity and low dissolved oxygen can occur at either the removal or disposal sites and in either the water column or the sediments. Estimates of free sulfides released to the water column should be made based on measurements of the free sulfide concentrations in the interstitial water and the water column. Elutriate test data should not be used to estimate this value because of oxidation of free sulfides during the test.

Toxic Organics. Processes which affect the chronic toxicity of DDT and PCB compounds are not well understood. Accumulation in the food chain has been documented for benthic, aquatic, and terrestial organisms. In the water columns, accumulation may result from exposure to soluble forms or injestion of particulate-adsorbed forms. Only the latter form appears to be affected by dredging and disposal operations. In the absence of direct evidence of acute or chronic impacts, dispersal of sediments with high toxic organic compound concentrations over a wide area should be identified as a negative impact.

Concerns. Are significant quantities of organic particulates and fines typically present in the water column?

If so, are areas identified which will have lower velocity regimes from dredging than presently exist?

In the areas which will trap organics, are the reduced sulfide capacities high enough so that hydrogen sulfide toxicity will be avoided?

Are free sulfides or a low reduced sulfide capacity present in the dredge material? If so, are potential impacts from free sulfides quantified and described?

4.1.2. Hydraulics and Hydrological

4.1.2.1. Circulation and Mass Transport

Description of the environmental impacts should be quantified directly from estimates derived from the physical parameters specified in GM 3.1.2. Except perhaps for maintenance dredging projects, measured data for the impacts may not generally be available and estimates must be obtained from analytical, physical, or numerical models (TM 2.2). It is important that both chronic and acute impacts be identified. Chronic impacts should be emphasized in the far field or total estuarine system. When seasonal factors significantly affect the acute impacts, this seasonal dependence must be identified and its impact assessed. Emphasis for seasonal factors should be placed on the impacts on the near field or immediate project site.

Impacts on the following parameters should be assessed directly from the data described in GM 3.1.2.

1) geometry,
2) water column stratification,
3) tidal motions,
4) land drainage, and
5) surface gravity wave motions.

Geometry. Impacts on the changes in geometry must be accurately quantified on all required cross-sectional profile and plan view drawings since these changes contribute significantly to the estimates required to assess nearly all other physical impacts. Geometrical changes should be quantified in both absolute and relative (percentage) values. It is especially important to identify whether the removal site after dredging will be self-scouring.

(Near Field). Changes in the cross-sectional profile and in the plan view drawings must be explicitly given. Generally, the changes in cross-sectional profiles at the removal site are the more significant, while at the disposal site, changes in the plan view are the more significant. These changes must be quantified graphically on the required cross-sectional profile and plan view drawings. In addition, the relative changes in channel depths, cross-sectional areas, hydraulic radii, and tidal flat areas must be quantified. Seasonal influences due to changes in the mean water surface elevation must be clearly identified for these parameters.

(Far Field). Changes in the tidal prism and in the horizontal water surface area must be accurately shown on plan view and cross-sectional profile drawings. Relative changes in these quantities must also be included as well as any seasonal influences on the values.

Stratification. Changes in the salinity distribution throughout the estuary is one of the most significant environmental impacts resulting from dredging and, at the same time, one of the most difficult to estimate. The estuarine classification method proposed by Hansen and Rattray (TM 2.4.1.) has been recommended as an adequate method for classifying estuarine circulation based upon salinity distribution. Impacts should be assessed relative to this classification system. Since measurements of the salinity distribution following dredging will generally not be available, mass transport models (probably one-dimensional) must be employed to quantify these impact (TM 2.2).

(Near Field). In stratified estuaries, the chronic impact of the salinity distribution should be emphasized.

(Far Field). Chronic changes in salinity distribution must be clearly identified.

Tidal Motions. Tidal motions are sensitive to changes in geometry, especially to changes near the inlet to the estuary. Tidal dynamics are the primary driving force for keeping inlets open from ocean waves which carry littoral transport into the inlet. Tidal currents are necessary to scour littoral drift from inlets and to maintain mass transport within the estuary. Changes in tidal amplitudes due to dredging will alter the driving force and changes in tidal velocities will impact the littoral drift rates and dispersive mass transport. As such, predicted changes in velocities from dredging should be included.

(Near Field). Changes in velocities will alter the ability of the removal area to maintain the dredged geometry. The impact on the disposal area will be to reduce the ability of the area to retain the dredged material and prevent erosion.

(Far Field). Changes in tidal prism will alter the tidal driving force into the estuary. Changes of the average and maximum values of tidal velocities at the inlet are significant impacts.

Land Drainage. Changes in commercialization due to dredging will impact on the natural drainage patterns by redirecting normal drainage fields and by increasing runoff due to surfacing of natural drainage areas. These impacts usually result in increased discharges and in an increased input of pollutant materials through storm drainage systems. A simple estimate of increased discharged should be computed using the rational method (TM 2.5).

Surface Gravity Wave Motions. Changes in geometry will alter the intensity of swell entering an estuary through an inlet and the type of local seas generated. Increased ship and boating traffic will increase ship wave generation. These impacts may be assessed through the wave statistics and wind data described in GM 3.1.2. (TM 2.6). The specific impacts include changes in the littorial transport near the inlet and resuspension on tide flats.

Concerns. Are changes in cross-sectional and plan view geometrics shown?

Will the proposed dredging action alter the estuarine classification under the Hansen and Rattray (TM 2.4.1.) system? If so, are the old and new classifications noted?

Are the changes in the dispersive mass transport from the dredging project identified (TM 2.2.)?

Are alterations of the tidal prism and velocities of the estuary shown (TM 2.3)?

Will the proposed dredging project impact or the surface gravity statistics of the estuary (TM 2.6)?

Are increases in the discharge rates derived from surface land drainage calculated?

4.1.2.2. Groundwater

Groundwater contamination will most likely occur where sandy soils overlay an actively used aquifier. The leachates from the land disposal area can readily permeate the soils to the groundwater source. Groundwater contamination should be considered as a probable impact when a polluted dredge material is placed in land disposal over a sandy soils which overly an aquifier. The existance of sandy soils and aquifiers can be ascertained from well logs and U.S. Geological Survey surficial maps.

The nature of the leachate can be best approximated from the solubilized constituents in the standardized elutriate test. The remaining bulk constituents probably will not be released to interstitial water at any significant rate. The elutriate test results will represent a conservative estimate since many of the constituents will be sorbed in the various overlying soils before reaching the groundwater.

Simple hydrologic models can be used to estimate the concentration increase in the groundwater from the disposal leachate. These values should be compared to the required values for the use of the groundwater. For example, if the groundwater is used as a drinking water source, then the U.S. Public Health Service drinking water standards should apply. The expected increases of pollutants in the groundwater and the required concentration to maintain its usage should be listed.

Various methods have been employed to reduce leaching from diked disposal areas. The dikes can be sealed with plastic sheeting, with clay linings, or by a fine-grained dredge material. Consideration of these methods should be documented where potential contamination problems could occur.

Concerns. Do any of the land disposal sites exist over sandy soils which overlay aquifiers? If so, is potential leaching of material from the dredge spoil examined?

4.1.3. Geological

Geological impacts may result if significant changes in sediment erosion and deposition occur. At a given location, geological impacts may manifest as changes in bathymetry, grain size, water content and organics content. Impact assessment, however, must be sensitive to the project's effect on removing essential elements of change as well as introducing foreign elements of change (TM 4.1.1.).

4.1.3.1. Changes in Sensitive Landforms

Erosion of sedimentary landforms will occur if the intensity and duration of local velocities are increased due to additional wave exposure, accelerated tidal currents, increased ship wake activity, etc. The new hydrodynamic conditions should be compared to the erosion resistance of the in-situ material to assess this change (TM 4.4.1.). The erosion resistance is a function of grain size and cohesive properties.

The creation of navigation channels may reduce flow in adjacent shoal areas. Also, hydraulic structures such a jetties and dikes, constructed to complement the project, may shelter some areas. The net result will be siltation and reduced sediment turnover in areas where hydrodynamic disturbances are reduced (TM 4.5.1.). Those areas should be identified on hydrographic charts. Siltation will be significant if an existing source of suspended fine material occurs with sufficient quantities of settleable material. This condition will be aggravated if local salinity is also increased due to induced changes in circulation patterns. Flocculation of fines could result in accelerated siltation.

4.1.3.2. Textural Changes

Sediment grain size distribution will change if the deposition process is modified via induced changes in circulation and salinity patterns or if deposited spoils differ significantly from in-situ material. An increase in mean grain size is to be expected if local velocities increase or if littoral sediment sources are accentuated relative to fluvial sources (TM 4.5.2.). A decrease in mean grain size will occur if floculation and settling are induced by an increase in salinity and decrease in velocity. These impacts require a suitable source of transported sediments.

If the local grain size structure is well graded, i.e., both coarse and fine fractions exist, then an increase in local erosion due to accelerated currents or wave activity can increase surface grain size by selectively removing the fine material from the sediment (TM 4.5.2.). This process can result in a reverse graded filter which effectively armors the sediment from further erosion. Thus, surface features become more coarse while material at depth remain undisturbed. Surface biota that are sensitive to grain size will respond accordingly. A narrative describing the estimated change in grain size and its indirect impacts should be included.

In addition to changing the texture of surface sediments, it is possible that sediment transport activity may change without any increase in net erosion or deposition. Ideally, a navigation channel is designed to be self-scouring so that it is in equibibrium with the dredged hydraulic radius and revised currents. This is accomplished when deposition is equal to erosion and both are non-zero. Proper selection of channel cross section area relative to mean flow conditions can assure equilibrium, but may increase or decrease the sediment load. The induced change in the sediment load will change the suspended solids concentration levels near the bottom which may impact filter and deposit-feeding biota.

4.1.3.3. Changes in Relative Distribution of Solids and Liquids

The water content increases significantly if a sediment is disturbed, especially if the material is eroded and deposited or mechanically mixed in place (TM 4.5.2.). This disturbance results in a dilation of the sediment pore spaces which fill with water. The water will be squeezed from the pores only if the material is allowed to rest under a load. This consolidation process occurs rapidly in coarse sediments (minutes), but slowly in fine, coehesive sediments (years). As a result, disturbing fine grain sediments may result in a permanent increase in water content of surface sediments unless these materials are subsequently buried at great depth for many years.

Sediments which have been disturbed are generally weaker in their dilated condition (TM 4.5.2.). This makes them more susceptible to continuous erosion. Also, bearing strength is reduced so the capacity to support macrofauna is decreased. Areas in which fine-grained sediments will be disturbed by the dredging projects should be shown on plan view maps to allow comparison with habitat locations.

There are also circumstances which could cause a decrease in water content. If dredging to project depth requires the removal of many meters of heretofore undisturbed material, the exposed material could be in an overconsolidated state. Furthermore, if the dredging project does not significantly increase local velocities and sediment mixing, then the material will remain at a water content or porosity level less than that of the original surface sediments. The resulting sediment matrix may resist further erosion but be too strong for certain burrowing biota to repopulate. This area should also be noted on hydrographic charts.

4.1.3.4. Changes in Solid Constituents

The organics components in sediments tend to be of low specific gravity relative to the mineral and inorganic fractions. As a result, organics respond to hydraulic disturbances similar to fines. That is, they are selectively removed if erosive conditions are increased and are deposited if transported to a region of reduced load carrying capacity (TM 4.4.2.). This causes nutrients to be removed from areas of increased hydraulic activity and to be deposited in sheltered areas. Proportionate changes in benthic chemical and biological activity is to be expected. These areas should be shown on the same charts required to show changes in sensitive land forms.

The removal of surface shell fragments and other biological debris may accelerate local erosion if these materials are armoring the sediment surface. Deposition of spoils onto an area protected by shell fragments may result in rapid erosion of the unprotected spoils.

4.1.3.5. Concerns

Are potential changes in the relative contributions of littoral and fluvial sediment sources from the creation of navigation channels and complimentary structures estimated?

Are sensitive land forms which could be eroded by increased hydraulic disturbances identified?

Have essential elements of change required for periodic reworking of sediments been identified? Will these be removed by stabilization of the inlet channels?

Have the effect of protective shoreline structures or spoil deposits on long term siltation in sheltered areas been noted?

Have the expected changes in surface grain size distribution been described?

Has the estimated change in organics due to increases in hydraulic disturbances been included?

Is an increase in sediment water content due to dredging, spoiling or more intense hydraulic mixing of surface sediments predicted?

Is removal of natural armor identified?

4.2. BIOLOGICAL IMPACTS

The biological impacts of a dredging project should be assessed from the background biological data (TM 3.2.) and from analysis of the various chemical and physical impacts. The predictions of some of the impacts is generally straight toward (i.e. destruction of benthic habitats) while others are extremely difficult. Biota respond intricately to physical and chemical conditions and judgement is required as to which impacts are important or which approach should be used to assess the impact.

The biological impacts are highly dependent on the phase of the project (removal or disposal) and, for the removal phase, the type of project (new or maintenance). As such, the structure of this section is based on the impact associated with each category (Fig. 4.1.).

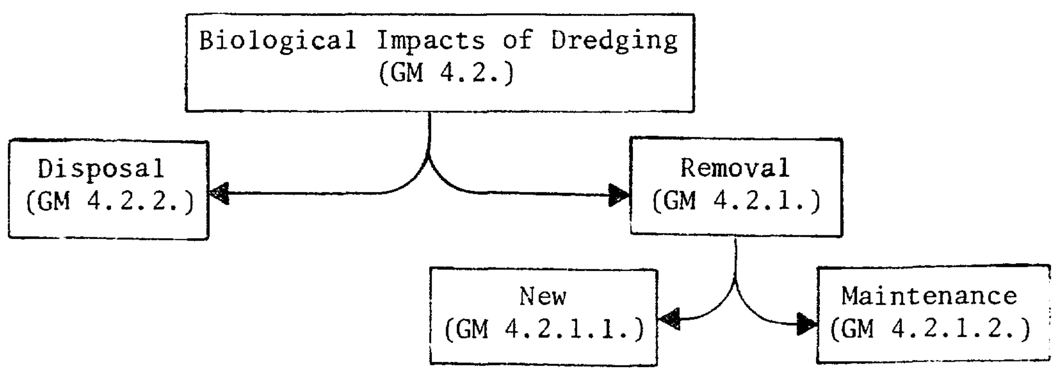


Figure 4.1. Organization of Section 4.2

Sometimes the identified impacts of a project can be mitigated by restoring or creating an area of the estuary to replace habitat lost to dredging or filling operations (TM 5.12). If mitigation is employed, the impacts of this action should be considered under project alternatives.

4.2.1. Dredge Material Removal

4.2.1.1. New Projects

A new dredging project offers the greatest possibility for adverse impacts. Although the most immediate impact will be felt by benthic organisms at the site, the nature and character of the estuary may be so changed that the impacts are very widespread.

Habitat Removal. Benthic organisms and their associated habitats in the dredged area will be removed or disturbed. After dredging, the altered habitats may or may not be suitable for recolonization from surrounding areas since underlying sediments may have significantly different chemical and physical properties. A benthic community identical to the original community may re-establish itself if enough time passes without new disturbances occurring (TM 5. Biological Impacts). As such, habitats in the dredging area which cannot tolerate frequent disturbances (e.g. sub-tidal clam beds, eelgrass beds) should be considered to be irreversibly destroyed by dredging unless specific information to the contrary is available. The location of these areas should be described along with the importance of the habitat to the estuarine ecosystem. Particular attention should be given to areas which contribute to production (either primary or secondary) or areas which have high standing stocks which are likely to be important in the diet of other species.

Studies of zooplankton are seldom required for dredging projects in estuarine areas in which waters frequently exchanged with oceanic waters. Other estuarine waters, however, contain endemic populations such as *Acartia tonsa* which has been shown to have benthic resting eggs which can be affected by dredging. The species list can be used to determine which type of zooplankton are present.

Salinity and Velocity Alterations. Dredging normally increases both the depth and the width of a shipping channel. This can change the circulation, either in a major way which involves the tidal prism of the whole estuary, or in a minor way involving a relatively small part of the bay. Changes in circulation can directly alter salinity, oxygen and velocity profiles in the near and far field (TM 2. Hydrodynamics and Circulation).

Many organisms are suspension feeders, sieving out food particles from the surrounding water. Changes in the circulation can alter the quantity and type of food available. The dispersal of larvae of many species may also be affected by circulation changes. If the water continues to circulate in similar patterns or is richer in nutrients, the effect can be negligible or even beneficial.

The velocity of water is very important to several types of deposit feeding organisms. Increased sedimentation may act to bury them, while decreased rates of sedimentation can alter their food supply. Potential habitat alterations can often be identified from careful analysis of the location of important species in relation to areas which will have altered circulation.

Large changes in the salinity and velocity profiles, identified as shifts in the classification system proposed in GM 4.1.2.1., should be considered to be a significant biological impact. The prediction of exactly how this impact would be manifested is presently extremely difficult. Benthic and pelagic species which are known to be sensitive to oxygen or salinity changes should be identified from the species list, when possible.

Estuaries often serve as spawning, feeding, and nursery areas for fish, shrimp, crabs and other important animals (TM 5.2). The calm, nutrient-laden waters are the ideal habitat for many fish larvae. The destruction of the estuary through pollution, filling, or turbidity destroys this valuable natural function.

Turbidity Increases. Increases in turbidity at the dredging site can be estimated from the data required in GM 4.1.1.1. Very few species have been shown to be affected by short-term turbidity increases. Those that are severely disturbed are generally sedentary filter feeders. Migration and/or reproduction of important or sensitive species during the dredging operation should be considered relative to the potential effects of turbidity on these processes. Scheduling the dredging to avoid times when important life stages are present in the estuary should be considered.

Alterations of Sediment Properties. Analysis of sediments as outlined in TM 4.1.3. will show areas where sediment changes can be expected. If these areas coincide with critical habitats, a statement concerning the potential impacts on the biology should be included. Particular attention should be given to shifts in grain size distribution and sediment organic content.

Chemical Alterations. The more important benthic chemical alterations will involve concentration of organics and toxic materials in the removal area due to changes in the sediment transport rates (GM 4.1.1.2.). If these impacts are predicted, then such areas should be identified as permanent losses of habitat and discussed as such.

Erosion of Tide Flats. The generation of waves can result in the erosion of tide flats both in the "near field" and "far field" (TM 4.1.2.1.). Impacts of this nature should be expected to have significant biolgocial impacts and should be identified as a permanent loss of habitat.

Secondary Impacts. Once a channel has been dredged it must be maintained. Subsequent dredging will extend the impact of the original dredging project. E.I.S.'s written on new projects must include maintenance dredging impacts on the biota and the effects of increased disposal areas.

Dredging and subsequent industrialization can result in combined and often cumulative biological impacts. Existing or potential commercial fishing interests, aquaculture programs, and recreational facilities may be diminished or lost (GM 2.2). These possibilities should be addressed, particularly where new dredging development projects will likely encourage new development.

4.2.1.2. Maintenance Project

Dredged channels often fill with sediment and must be continually dredged. Maintenance dredging, as a sporadic disturbance, can keep the resident biological community from reestablishing itself. Moreover, maintenance dredging often requires disposal of chemically polluted sediments which have been generated after completion of the original project.

The biota in the project vicinity will change to one which is adapted to the altered conditions. As such, the dredging area will become a new habitat with a particular disturbance frequency. Species tolerant of frequent sediment disturbance will remain in or colonize heavily dredged areas. Habitat removal, salinity and velocity alterations, and alterations of wave patterns from maintenance projects are typically less pronounced. Maintenance projects which have not been maintained to full authorization may have to be considered as new projects.

Habitat Removal. A continued removal of benthic sediments can disrupt the life cycle of some species. Especially sensitive are those pelagic organisms which depend on the benthic environments for resting egg stages in their development. Such species, where known, should be identified from the species list.

Turbidity. The potential effects of chronic turbidity on biota of frequently dredged or disturbed areas appear most likely to affect sedentary filter feeders especially if a "fluff" condition at the benthic boundary layer is formed. Environmental assessment of projects near shellfish or other suspensions feeding communities therefore should consider turbidity. Scheduling the dredging to avoid times when important larvae or other life stages are present should be noted as in GM 4.2.1.1. However, continual maintenance dredging of fine grained sediments can lead to chronic turbidity in the water column. Some intolerant filter feeding invertebrates, commercial shellfish, and species low on the food chain which support the commercially valuable species, may not survive frequent disturbance and high turbidity levels. Acute turbidity impacts on the biota can be assessed as described in GM 4.2.1.1.

Sediment Properties. Continual maintenance dredging can result in a continual shift of sediment properties as described in GM 4.1.3. With each iteration of removal, the chronic impacts will become more prevalent. The importance of changes in grain-size, organic content, sediment transport and water content to the habitat of important species and their interactions should be described.

Secondary Impacts. Pollution from the shore of the estuary or from up river is a very important factor to be considered for both new and maintenance projects. Increased industrialization will probably extend building on both the shoreline and into the river. These changes must be considered for possible impacts on the biota.

4.2.2. Dredge Material Disposal

4.2.2.1. Disposal in Estuaries (Open Bay Disposal)

Disposal of dredged material in estuaries offers a very high potential for biological impacts. Large quantities of solid materials are added to the water column as both particulates and solutes.

Areas of high production are the most sensitive to disposal impacts. Turbidity may cause light limitation to photosynthetic algae and plankton; however, the extent of this impact is presently unknown. Changes in water circulation from bar buildups or spoils islands may affect tidal prisms and drainage of valuable wet lands. Possible release of toxic substances from the disposed material may extend the boundary of impacted area.

Burial. The deposition of material in the disposal area can result in burial and smothering of both plants and animals. Generalized knowledge is available concerning the types of animals which can withstand high deposition rates (TM 5.7). Estimates should be made from the species list as to which species will be impacted by the total depth of deposition or the deposition rate. Burial is important for aquatic plants such as benthic algae and eelgrass, as well as invertebrate species (TM 5.7).

Recolonization. Some destruction of benthic biota will always occur at the disposal site. This impact will be minimized if the dredge material is compatible with the sediments at the disposal site. Compatibility can be assessed by comparing various physical and chemical parameters (GM 3.1.1.2. and 3.1.3.). With compatibility, recolonization can be assumed as probable. Without compatibility, destruction of habitats should be expected. The time required for recolonization is dependent on many factors such as species and season, and typically cannot be estimated (TM 5.7).

Solubilization of Chemical Pollutants. Various toxic and environmentally damaging pollutants can be solubilized from the disposal dredge material; potentially significant chemicals are free sulfides (if present) and ammonia. Other substances which may be of importance in isolated cases include various heavy metals and oxygen-consuming compounds. Biological impacts should be assessed from either predicted concentration levels (TM 4.1.1.1.) and/or acute bioassays (TM 5.13). Narratives should be included concerning the effect of toxic compounds which are known to be present.

Uptake of Chemical Pollutants. New chemical pollutants (heavy metals and toxic organics) may be introduced to the sediments at the disposal site from the mixing with dredge material. These consitutents may have chronic impacts on the biota from long-term uptake. Uptake of these constitutents, if present, should be estimated from long-term bioassays (TM 5.13) using organisms known to exist at the disposal site.

Turbidity. High concentration of turbidity will be associated with all aquatic disposal operations. Its effect on pelagic recruitment larvae, nearby shellfish beds, and benthic filter feeders should be discussed.

4.2.2.2. Deposition In Wetlands

Destruction of Habitat. Since 1972, filling of wetlands has been controlled by law. When filled, a salt marsh, a mud flat, or an eelgrass bed is significantly altered as a biological unit and ecological relationships with other parts of the estuary are usually affected. As an example, decomposition products from wetlands provide a great deal of nutrients for the rest of the estuary and without these nutrients the total productivity of the estuary will decline. Salt marshes often function as pollution assimilators, in effect providing for tertiary treatment wastes. Marshes also provide food and shelter for many terrestrial species. Flood water can be accommodated by marshes much better than by filled land. Mud flats provide food sources for many organisms which include commercially important fish, shellfish and water birds. Eelgrass beds provide food and shelter for many species. Quantification of these areas to be filled from the disposal need to be listed, along with the total quantity of wetland available. The habitats present in the areas to be filled need to be clearly identified. Interrelationships between the wetland and the estuary need to be described so that the impacts of filling can be properly predicted. Presentation of data on the amounts of like habitats previously filled are also useful.

4.2.2.3. Upland Disposal

Uplands are often practical sites for dredged material disposal, especially dredged material which is expected to have adverse impacts in the water column. Uplands are areas which lie above the upper margin of the wetlands (naturally vegetated areas between mean high water and maximum flood water). The uplands, especially those in the flood plain, have a potential for impacts on estuarine and coastal waters, as well as the terrestrial environment. Subsequent development of upland sites can also affect the estuary and such development should be discussed. Impacts to the terrestrial environments are not described herein.

Runoff. If the dredge spoil is contaminated with chemical pollutants, then these pollutants can leach through runoff into the estuary. Potential toxic effects to biota from the known chemical composition should be described.

Important considerations for the effects of upland disposal on estuaries result from increased sediment transport and pollutant solubilization from runoff. Evidence of proper containment should be presented. Changes in drainage water patterns into the water or across the wetlands may affect the biological populations through changes in feeding or resting areas, and can modify nutrient inputs.

4.2.2.4. Open Ocean Disposal

Disposal of dredged material in the open ocean is a common method of disposal of dredged material. The environmental effects of this method of disposal are not specifically covered herein.

4.2.3. Concerns

4.2.3.1. Removal

Are the habitats in the dredging removal area adequately identified and described? Is the potential destruction assessed for those habitats and populations sensitive to disturbance?

Have adequate physical chemical and geological data been presented to assess biological impacts on habitats? on species?

Are habitats which could be destroyed by changes in sediment physical and chemical properties identified and located? Are they discussed relative to the possible changes in the biota?

Are species which are likely to be sensitive to hydrographic changes (temperature, salinity, velocity, wave erosion, turbidity, tidal prism, nutrients, organics) identified?

Have location of species likely to be susceptible to turbidity been correlated with areas which may encounter increased turbidity?

Has information on migration and reproduction of commercial recreational or sensitive species been presented?

Have potential impacts on habitats been related to natural functions of the estuary?

Have the impacts on the biota from concentration of organics and toxic material in the removal area been adequately discussed?

Will subsequent maintenance dredging be required? Has its potential for continued impacts been described?

Have the impacts of changing use of the estuary (industrialization and urbanization) been discussed relative to the biota?

4.2.3.2. Disposal

Has the physical and engineering data on containment been adequate to predict possibly impacts to habitats and species? Is leaching a likely problem?

Have the habitats in the estuary or wetlands which may be impacted been adequately described? Is potential destruction assumed for those habitats sensitive to disposal?

Are species in the disposal site which will be buried or smothered identified?

Is the aquatic disposal area assumed to be able to recolonize based on the frequency, and rate of disposal and compatibility of the disposal material?

Has the uptake of solubilized toxic chemicals by biota at the disposal site been estimated?

Have effects of increased turbidity from disposal been considered?

Have effects of subsequent industrialization or urbanization on land disposal sites, or the estuary been considered?

4.3. HUMAN IMPACTS

4.3.1. Economics

A dredging project has economic impacts which must be considered from both the national and the directly impacted region's point of view and possibly other subareas in which economic effects are identifiable and large (TM 6.2.1.).

4.3.1.1. National Economy.

From a national economic point of view, the relevant impacts are the effects of the project on national economic efficiency and therefore on the size of the potential gross national product (GNP). They include both intended and unintended impacts.

Intended Impacts. The intended impacts of most dredging projects are 1) the benefits which accrue to the direct users of the channel and 2) the costs which are incurred in the initial dredging and subsequent maintenance of the channel. The direct users for most projects are confined to waterborne transportation companies and sometimes fishermen, either of whom could not operate in the specific waterway without the channel improvement, or could operate, but only in a less efficient way (e.g. use of smaller vessels). Users of the channel who would have operated in the waterway in the same manner without the project should not be treated as beneficiaries of the project. Virtually the only benefits to waterborne commerce and fishing which can be attributed to the project are the cost savings which result from the use of the channel (rather than the next best alternative route which would be used in the absence of the channel). Other intended but usually incidental benefits may occur including land site improvements resulting from the disposition of the dredge materials (TM 6.3.1.).

Unintended Impacts. The unintended impacts result primarily from alterations in the environment. They can be either positive or negative, but in most instances they are negative.

(Quantifiable Unintended Impacts). Where possible, these unintended effects should be quantified using standard capitalization procedures and other measurement techniques. This is possible in cases in which currently utilized commercial fishery or recreational resources are affected. These constitute known and measureable unintended impacts. Other unintended impacts are unknown and/or are not amenable to measurement or if measureable are not susceptible to valuation in social welfare terms. In instances in which mitigation (repairing environmental damage or creating replacement environments in lieu of those damaged or destroyed, TM 5.1.2.) is required, dollar measures of some of these otherwise difficult to measure costs are available. The measureable costs and benefits must be made comparable by conversion to present value terms. This requires the selection of an appropriate discount rate (TM 6.3.3.).

(Nonquantifiable Unintended Impacts). The costs (or benefits) of unrepaired environmental changes which also do not involve resources of current commercial value cannot be quantified by any widely accepted methodology. Consequently, they can not be combined with the measured impacts in a single definitive benefit-cost measure. Hence, the measured benefits and costs alone are not a sufficient basis for judging the desireability of a project from the point of view of society. Despite the ambiguity of the other impacts, they should be given weight in the decision process, particularly if the measured benefits and costs are close to being equal (TM 6.3.3.).

4.3.1.2. Directly Impacted Region

The directly impacted area will experience an increase in production activity. These production impacts give rise to various nonproduction economic impacts and other social impacts.

Direct Production Impacts. The direct production impacts include the actual dredging operations and the activities of the direct users of the channel. They, in turn, give rise to indirect production impacts (TM 6.4.1.).

Indirect Production Impacts. The indirect production impacts result from 1) expenditures financed directly and indirectly by revenues which are initially brought into the area by the dredging and channel dependent activities (direct production impacts) (TM 6.4.1.), and 2) changes in supply conditions and structural characteristics of the area economy which result directly and indirectly from the project (TM 6.4.1.). The indirect expenditure linked activities are classified as 1) backward linked input supply, 2) induced consumption, 3) induced government and 4) induced private capital investment. The activities resulting from changes in supply conditions and structural characteristics are classified as 1) forward-linked and 2) agglomeration-metropolitan. Figure 4.3.1. illustrates these indirect relationships and the interrelationships among the various indirectly impacted activities. These impacts should be quantified. Note, all are not included in the aggregate impact estimates of some of the regional impact models in their typical usage (TM 6.4.2.).

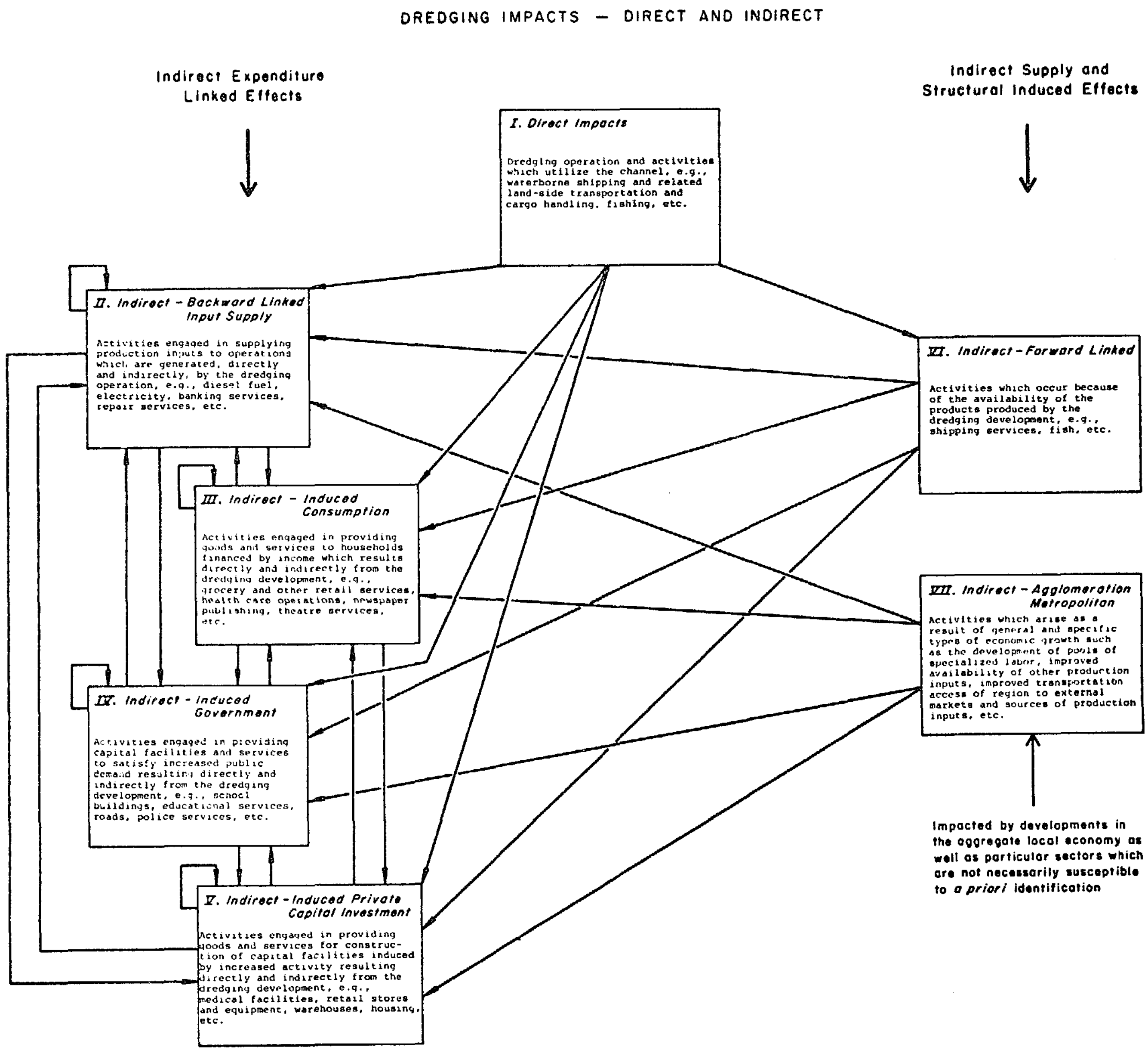


Figure 4.3.1. Summary of Direct and Indirect Dredging Impacts.

These indirect impacts differ in their timing, magnitudes and probability of occurrence. Impacts II and III are certain to occur and with a very short time lag following activity in I. Impacts IV and V occur with a longer time lag and only if the magnitudes of the changes in production activities I, II, III, VI and VII result in increased demands for services in excess of existing unused capacities in public and private capital facilities and underutilized levels of current government and commercial services. Impact VI occurs if the channel induces activities to locate in the area which are directly dependent on the output produced by the channel users. Seafood processing and industries dependent on the processing of waterborne imports are examples of activities which fit this classification. Impact VII depends on the size of the total impact as well as the size of particular impacts. For example, project induced growth in economic activity which results in the development of new or improved transportation access to the area may enhance the area's desireability as a location for new activities (TM 6.4.1.).

Other Economic Impacts. The sum and character of these production impacts are responsible for other economic impacts which include 1) fiscal effects (local government expenditure and tax consequences), 2) occupational and employment mix effects, 3) employment and unemployment effects, 4) per capita income effects, 5) migration effects, 6) local price effects for land, housing, water and energy, 7) land and water use effects which have implications for local land use and water plans, 8) local supply effects involving availability of various consumption and production goods and services, 9) congestion, travel time and other travel cost effects and 10) air, noise and other pollution effects (TM 6.5.).

With respect to the directly impacted region, it is the quality of life consequences brought about by these other nonproduction economic effects, not the aggregate production effects, which constitute the appropriate input for the project selection process (TM 6.5).

4.3.1.3. Concerns

Are the impacts for the national economy clearly distinguished from those for the directly-impacted economy?

Are the measured benefits and costs appropriately limited to net benefits and net costs (TM 6.3.1.)?

Are the data sources and estimation procedures identified and defensible?

Has an appropriate discount rate been employed (TM 6.3.5.)?

Is it clear which direct and indirect impacts are included in the reported aggregate production impact (TM 6.4.1.)?

Are the reported aggregate production impacts inclusive of all impacts including both short run and long run impacts (TM 6.4.1.)?

If the estimates of the indirect impacts are derived by use of an analytical model, do the parameters of the model constitute average or marginal coefficients (TM 6.4.2.)?

Is it understood that different analytical techniques (economic base, intersectoral flows, input-output and econometric) when utilized in a typical manner measure different indirect impacts (TM 6.4.2.)?

Are ambiguous data measures such as sales and units of physical output avoided or supplemented by employment, value added, personal income or other measures which are less ambiguous (TM 6.4.2.)?

Have the area impacts been reported, displayed and summarized in a manner that is clear and enables ready comparison with similar impacts arising from other projects (TM 6.5.)?

Is it understood that the regional impacts which are relevant to the project decision process are the nonproduction, quality of life consequences (fiscal, price, pollution, unemployment, per capita income, etc.) (TM 6.4.)?

4.3.2. Social

Assessment of sociological (or social) impacts should provide a clear statement of what life might be like in those communities in the immediate vicinity of the project and in other affected areas. The focus should be on the kinds of social changes which are most attributable to the project, and some effort must be made to distinguish these changes from general changes which are likely to occur regardless of the project. Obviously, this is a big order, especially since social impact assessment must, in large part, rest on fluid and often unpredictable changes in human behavior. Despite these uncertainties, it is possible to outline several guidelines which can be used to evaluate the adequacy of social impact assessment.

4.3.2.1. "Match" Between Description and Impact Variables

Estimation of impacts should be organized around the specific variables or topics described by the background data. This is important because it makes little sense to discuss future conditions without a clear notion of past and present conditions.

4.3.2.2. Compliance with Agency Guidelines

Discussion must include those variables which the agency itself requires in each Environmental Impact Statement. For example, Section 122 of the Rivers and Harbors Act (and the guidelines subsequently published by the Corps of Engineers) specifically requires assessment of impacts on social variables such as housing, community cohesion, and population growth. It is also important to check on any Corps Division or District policies which might call for the inclusion of additional impact variables.

4.3.2.3. Linking Economic, Demographic, and Other Social Change

Since many of the most significant social changes occur in response to population (demographic) change, discussion of economic impacts must be linked to analysis of non-economic social impacts in a way which allows exploration of population changes which might be generated by project-related employment and consumer changes (TM 7.4.3., 7.2.1.4.). While population estimates are admittedly "guesstimates," without some attention to likely population changes, one cannot begin to outline potential social changes in the various aspects of community life. In addition, population changes attributed to the project should always be compared with those expected to occur anyway. (Failure to do this gives the impression that all population change (often growth) is "caused" by the project.)

4.3.2.4. Labelling Impacts as "Good" Or "Bad"

Reviewers should be wary of discussions of social impacts which simultaneously describe likely impacts and assume that they are "good" or "bad" or "favorable" or "adverse." In many instances, of course, nearly everybody would agree on whether an impact is good or bad (nobody wants crime to increase). In other social areas, however, they may be substantial diversity of opinion about whether an impact should be considered favorable or adverse (population growth, community conflict or cohesion). Many assessments fail to acknowledge this diversity of perspective, and automatically assume that people are unanimous in their evaluation of the goodness or badness of identified impacts. (The place for agency "labeling" of impacts is in the section of titled "Favorable and Adverse Effects," rather than in the section on Environmental Impacts.)

4.3.2.5. Identification of Impacts on Different Communities or Groups

Analysis of impacts should make every effort to identify differences in the way in which segments of the community will be impacted. That is, communities are made up of different social groups; rich, poor, young, old, long-time residents, and newcomers (TM 7.2.7.). It is, therefore, nearly always incorrect to talk about the "community" as if it was a single group. Further, it is usually true that impacts are felt differently by different groups within the community (and by different communities or regions). For this reason, social assessment should include mention of those cases where impacts will hit only certain segments of the community.

4.3.2.6. The Basis for Impact Prediction

Assessment of social impacts should include mention of the basis for the prediction of the impact. Predicting the future is always difficult and risky, and this is especially so for human behavior. However, a variety of strategies can be employed to provide an informed estimate of likely impacts. As a starting point, evaluation of the adequacy of social impact assessment strategies would include a look at whether the assessment included information on how impacts were assessed, and whether a variety of strategies were utilized in a way which resulted in a comprehensive picture of the future. In most cases, one must assume that the "how" refers simply to the "guesstimates" of the individual(s) who actually wrote the report. This is, of course, only one "approach." Alternatives would include quantitative expression through a series of population multipliers (TM 7.4.3.), incorporation of "guesstimates" of persons with direct responsibility for specific social impact variables (TM 7.4.4.), asking citizens to help "guesstimate" the future (TM 7.4.5.), and comparisons with existing communities which have experience similar projects or social changes (TM 7.4.5.).

The question of the variety of assessment strategies is important because use of a single strategy (such as the population multiplier) seldom yields a comprehensive picture of likely impacts. A related consideration is that people have different concerns when they read the EIS's. School personnel want fairly detailed, quantitative estimates of changes in school populations, while the average citizen may be more concerned with general changes in the "character" of the community, or with impacts on specific occupational groups.

4.3.2.7. Social Assessment Timeframe

Descriptions of impacts should distinguish between those which are expected to occur in the near future (5-10 years), and those long-term changes. To ignore either is misleading. While it is understandable that agencies may prefer to focus on the more immediate and predictable short-term impacts, some identification of long-run community change is also important.

4.3.2.8. Concerns

Is there a good "match" between the social variables reviewed in the background section and those discussed as impacts?

Does the "picture" of the community which emerges give some "feel" for what life will be like in the future?

Are those changes which are attributable to the project highlighted?

Is a mix of qualitative and quantitative information used to portray impacts?

Does the discussion include treatment of variables required by agency guidelines?

Are these variables realistically discussed or are they dismissed with a "no significant impact" statement?

Are potential population changes explored?

Are population changes predicted on the basis of the project compared with existing non-project projections?

Is labeling of impacts as good or bad or favorable or adverse separated from a discussion of likely impacts? If not, is there some indication of the possibility of diversity of evaluation as adverse or favorable?

Does the discussion lump the population into a single category, or is there an effort to outline the relative impact on different community groups?

Are agency "guesstimates" identified as such?

Did the writers utilize more than one assessment strategy?

Does the discussion identify both relatively immediate (5-10 years) and long-term social impacts?