APPENDIX A

A TWELVE STEP PROGRAM FOR CONDUCTING A PRELIMINARY PORT AND WATERWAY RISK ASSESSMENT AND/OR A FORMAL RISK ASSESSMENT

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INSTITUTE FOR CRISIS AND DISASTER MANAGEMENT

March 1996

REQUIREMENTS FOR A
PRELIMINARY RISK ASSESSMENT

REFER TO FIGURE A-1

GATHERING INFORMATION: STEPS 1 THROUGH 3

Step 1: Identify stakeholders and experts

Stakeholder means, literally, a person or an organization that has a stake in the outcome. When a new or expanded use of the waterway such as the introduction of a chemical waterfront facility or high capacity passenger vessels operations is proposed, stakeholders will include the users, state and federal regulators, and other interest groups shown in table 1 in the basic report. *Experts* are individuals such as state pilots, mariners, port authorities, tow boat operators, and Coast Guard marine safety and aids to navigation personnel who have a deep knowledge of the local waterway system. Most experts are also stakeholders (e.g. pilots), but some (e.g. retired mariners, local researchers) are not. The experts will provide you with much of the information you require to conduct a preliminary evaluation of risk. *Worksheet 1* is provided to assist in identifying stakeholders and experts.

Step 2: Consult with stakeholders and experts

Discussions with the stakeholders and experts should provide the answers to three important questions:

1. How will the proposed risk analysis and proposed new uses of the port or waterway affect each stakeholder and what is their perception of the effect of the change on the current level of risk?

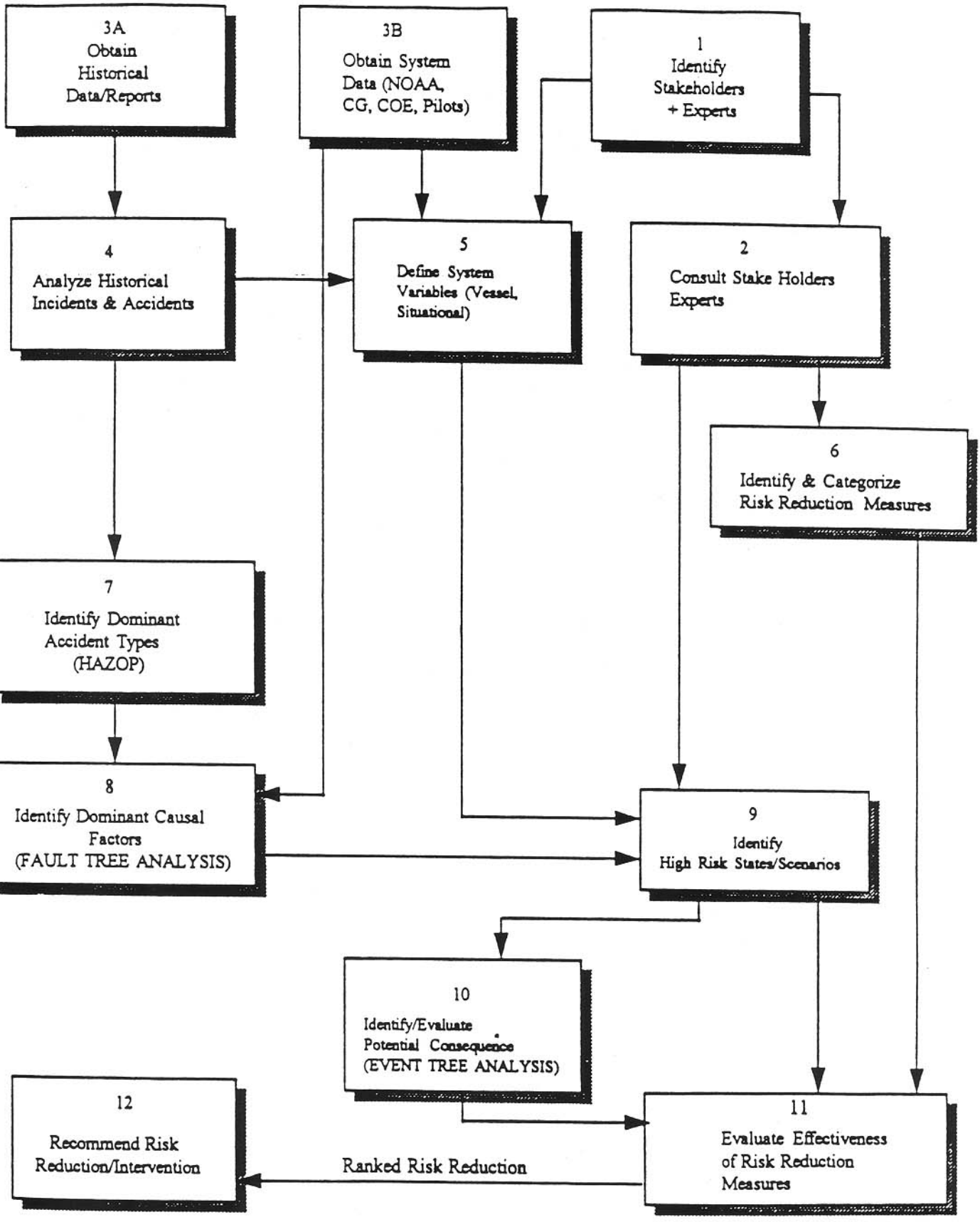


Figure A-1 : Flow Chart - Preliminary Risk Assessment

2. What are the most significant hazards (e.g collisions at traffic convergence points, groundings on exposed reefs) and situational risk factors (conditions that significantly increase the risk of the system such as low visibility, high river stage) in the waterway?
3. What risk reduction measures are in place that are unique to the port or waterway (e.g. COTP Orders, Notice to Mariners, escort procedures, industry practices), which of these measures are particularly effective, and what measures have been proposed?

Each stakeholder has an interest in any changes that may result from the risk assessment. Identifying these interests is essential for ensuring stakeholder acceptance of the risk assessment process and the results. Eliciting the stakeholder's perception of the current risk level and of changes in risk due to the proposed new uses is a critical activity. You will find that many non experts have difficulty in estimating the risk of low probability, high consequence events. Risk communication and risk education are important activities in any risk analysis. Incorporate these activities into your approach early, or your results will not be accepted by stakeholders. Stakeholders and experts are also a primary source for potential risk reduction measures (Step 6 below). Experts can provide invaluable local data on incidents, accidents, and near misses (step 3) and can help define what attributes of the port, waterway, and calling fleet contribute the most to the current risk level (step 5). Experts are capable of identifying the high risk system states (step 10). The dialogue between you and the stakeholders and experts should continue throughout the risk analysis effort.

Step 3: Obtain historical data/reports and system data

You are interested in the significant incidents that have happened in your area of responsibility, near misses that may have occurred, the types of vessels and situations that have caused problems, and the profile of the vessel traffic that uses the waterway. Potential data sources are listed in table 4 in the basic report. Coast Guard marine safety data systems are a good source of accident and incident data and the Army Corps of Engineers Waterborne Commerce statistics furnish traffic and cargo data. However, local data sources will probably provide the most useful information. The CG WAMS reports contain significant information on all reported incidents keyed to waterway location. WAMS

also contains a description of waterways hazards that will help define system variables (Step 5). Other valuable sources of local information are a Vessel Traffic System (traffic records, near miss and incident descriptions), state pilots (traffic and near miss information), and port authorities and marine exchanges (traffic data). Anecdotal accounts from experts should be used to augment and interpret the available local data.

FRAMING THE RISK ASSESSMENT: STEPS 4, 5, 6

Step 4: Analyze historical incidents and accidents

Remember that your task is to perform a preliminary evaluation of risk; not to conduct a full, analytic risk assessment. In a preliminary assessment, the analysis should be limited to identifying the records and data necessary to identify the dominant accident incident types (Step 6) and the dominant causal factors (Step 7).

Step 5: Define System Variables and States

Tables 1 and 2 in the basic report give suggested vessel description variables and waterway system variables. Each table provide suggested categories for these variables. Note that the categories are arranged in order of increasing risk. The number of allowable system states in your model is determined by the number of system variables and the number of categories defined for each variable. For the purposes of a preliminary risk assessment:

1. Construct a rough vessel type profile of the deep draft calling fleet, shallow draft transit fleet and shallow draft local fleet using US Army COE statistics or local data.
2. Estimate how often one or more high risk vessels are transiting the port and waterway system. Estimate the percentage of each vessel type that falls into each high risk category (see *Worksheet 2 for US flag vessels, Worksheet 2b for foreign flag vessels*).

For the preliminary analysis, expert judgement supported by easily available data (e.g. from the marine exchange) is an adequate basis for this activity. "High risk" at this point in the analysis is a relative term, you are looking for the vessels in the calling and local fleets most likely to be involved in an accident in your port. For U.S. flag vessels the first cut approximation is obtained by identifying the percentage of the domestic calling fleet that have a high risk value for one or more of the risk factors in worksheet 2A. For foreign flag vessels the first cut approximation is obtained by identifying the vessels that are evaluated as Priority I or Priority II vessels using existing USCG Port State Control criteria using worksheet 2B. Worksheets 2A and 2B should then be used to calculate the percentage of high risk vessels in the calling fleet, and the percentage of vessel transits made by these vessels.

3. Estimate the amount of time high risk states occur in your waterway. Identify the portions of the waterway that are open fairways, restricted waters or converging waters. Estimate the % of time the high risk states occurs for each type of waterway. (see *Worksheet 3*). Again, "high risk" is a relative term; the objective is to identify those states of the system when an incident or an accident is most likely to occur.

Step 6: Identify and Categorize Risk Reduction Measures

You will probably find that a large number of suggested improvements to the system have already been identified by prior studies, state and federal agency proposals, and proposals by maritime associations. Your consultations with experts and stakeholders will identify others. The purpose of this step is to provide some structure to this listing of concepts that will help you link your risk analysis not only to potential problems, but to potential solutions. A two dimensional categorization is suggested (*see worksheet 4*). The first dimension is determined by where the proposed action intervenes in the casual chain.

- Is it intended to prevent the errors, failures, or conditions that lead to an accident (e.g. training, traffic restrictions)?

- Is it intended to prevent an accident once a failure or error occurs (e.g. VTS)?
- Is it intended to minimize the consequences of an accident? (e.g. on board firefighting, external fire and rescue)?

The second dimension describes the type of intervention. Suggested intervention types are: Waterways Management and Traffic Control, Vessel Personnel and Pilotage, Vessel Equipment and Design, Inspection and Enforcement, and Emergency equipment and Procedures.

THE PRELIMINARY EVALUATION OF RISK: STEPS 7,8,9,10

Step 7: Identify Dominant Accident Types

Examination of the historical record and discussions with experts will reveal a relatively small number of dominant accident types. These types will vary among ports. River ports may find that collisions and allisions (with docks, moored vessels, and bridges) are the most frequent incident types. Ports in bays or sounds will probably see fewer allisions, but many more groundings. Congested ports with complex traffic patterns and river ports will see more collisions.

Step 8: Identify Dominant Causal Factors

This is the most difficult task in a risk assessment and in a full risk assessment will require either a fault tree analysis, a probabalistic risk analysis, or a statistical analysis of available data.. For the purposes of a preliminary risk assessment, an examination of the case records of the accidents identified in Step 7 and the use of anecdotal material from experts is sufficient. You may find, for example that most groundings were caused by a combination of weather and human error or by loss of propulsion.

Step 9: Identify high risk states and scenarios.

This step requires the integration of all the information obtained in steps 5, 7 and 8. High risk states are those involving a high risk vessel and/or a high risk situation as identified in worksheets 2 and 3. High risk states indicate conditions in which a small error or failure is likely to develop into a significant event. In a detailed risk assessment detailed traffic, weather, wind, and current data will be required to determine how often these risk states actually occur using sophisticated simulation or statistical models. In a preliminary risk assessment, however, you will probably have to rely on expert judgement. High risk scenarios are the causal chains identified is steps 7 and 8. High risk scenarios that are allowed to occur, and relatively high risk system states that occur in your port with non negligable frequency are your primary concerns. If you identify a high risk scenario that could occur in a high risk state, you have a significant and immediate risk management problem.

Step 10: Identify and evaluate potential consequences.

Risk is a product of probability of occurrence times the impact or consequence of the event. A detailed risk analysis should contain an event tree analysis or some other analytic method of determining the potential consequences of accidents. The quantitative evaluation of consequences is a difficult task. The value of a human life is not easily determined nor are the values to be attributed to natural resources damaged by pollution. A preliminary risk assessment, however, should be restricted to a description of potential consequences (e.g. significant loss of life, major oil spill, toxic release) for a reasonably selected set of risk scenario/risk state combinations. It is important to include the risk state in this exercise, since the state of the system (location, weather, etc) will determine both the availability and the effectiveness of response resources. (See *Worksheet 5*.)

RISK REDUCTION EVALUATION and RISK MANAGEMENT: STEPS 11 AND 12

Step 11: Evaluate Effectiveness of Risk Reduction Measures

The reason for the risk assessment is to provide a basis for determining how to make the system safer. Deciding what can and should be done are the the first and most critical functions of risk management. In step 6 you identified and categorized proposed risk reduction measures. In a quantitative analysis a rigorous methodology such as simulation, statistical regression modeling, or probabalistic risk analysis would be used to measure the potential impact of the proposed risk reduction measures. In a preliminary analysis, the objective should be to determine the feasibility of the proposed risk reduction measures. This can be done by comparing the table of risk reduction measures developed in Step 6 *(Worksheet 4)* to the table of risk scenarios, risk states and potential consequences developed in Step 10. You should attempt answer the following questions:

1. Will the proposed measure interrupt the causal chain of the risk scenario, prevent a risk state from occurring, or reduce the consequences of an accident? If it does not or if it increases the probability that a risk scenario or risk state will occur, no further evaluation is required.
2. Where in the causal chain does the measure intervene? Does it prevent errors or failures, or prevent accidents even if these errors or failure occur? Does it minimize consequences once an accident happens?
3. What is the relative cost of the intervention measure?
4. How technically, politically, and organizationally feasible is it to implement?

Step 12: RECOMMEND RISK REDUCTION MEASURES

Recommended risk reduction measures must make the system safer. You may find that some proposed measures have no effect or even make the system worse. The set of risk reduction

measures that should be recommended are those that are cost effective (see figure A-2). The measures in the upper left quadrant (low cost, high risk reductions) are clearly your first priority, assuming that they have passed the feasibility test implied by question 4 above. The measures in the lower right quadrant (high cost, low risk reduction) should not be considered further. Measures in the other two quadrants should be examined if the low cost, high risk reduction measures do not achieve the desired level of risk. You may wish to make those measures that intervene early in the causal chain your top priorities since they will undoubtedly be the cheapest and are often the most effective measures. This is a good time, however, to review stakeholder expectations since those measures that intervene late in the chain (double hulls, escort tugs, external controls, response equipment) are often preferred. They are highly visible and easily verified when compared to the more global measures that attempt to improve organizational and human performance.

Risk Reduction Measure

Cost Versus Effectiveness

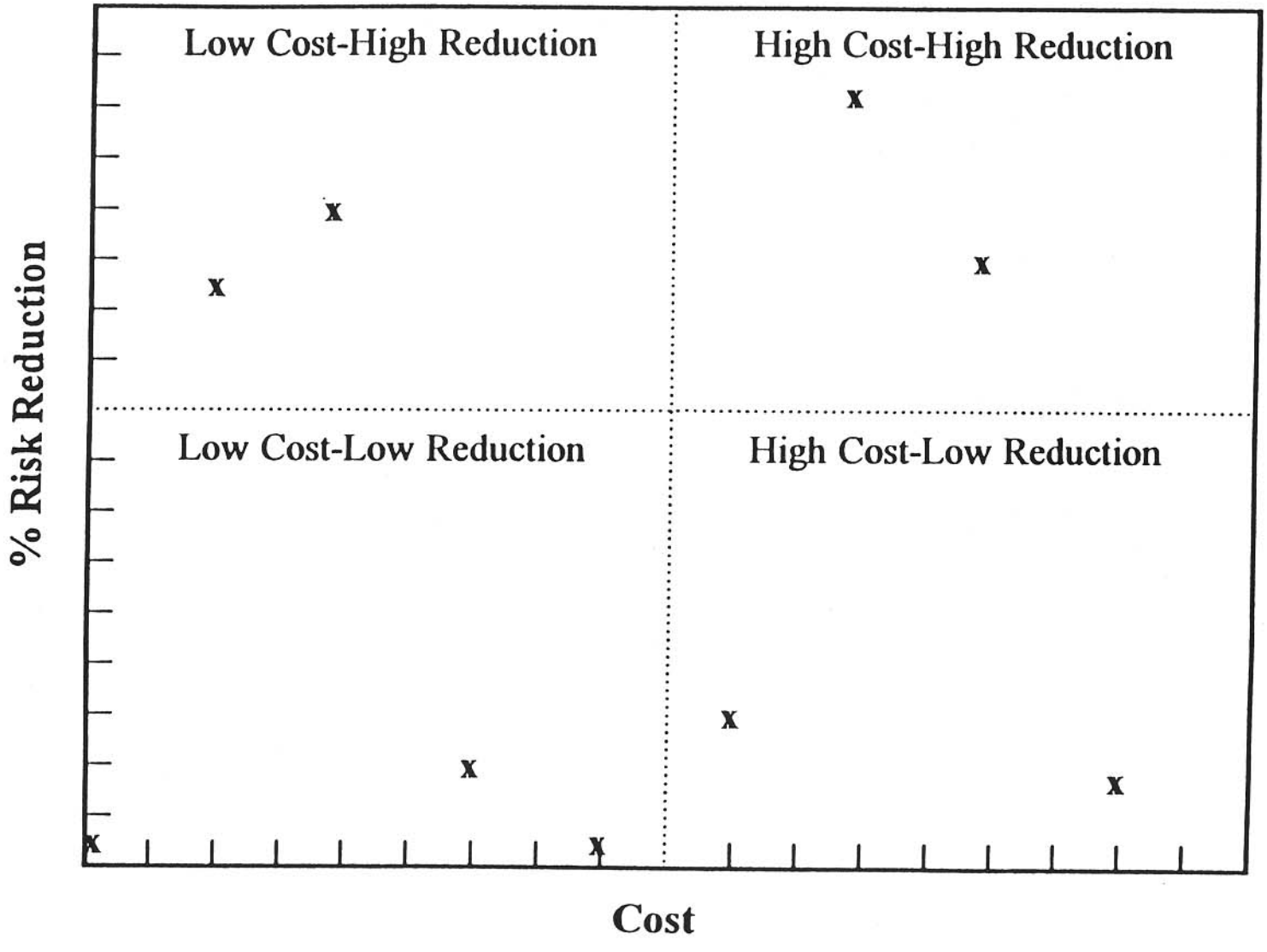


Figure A-2

REQUIREMENTS FOR A FORMAL RISK ASSESSMENT

REFER TO FIGURE A-3

A full or formal risk assessment will differ from your preliminary risk assessment in two significant ways:

1. The objectives of a formal risk assessment are *to quantify* the baseline risk, the contributions of causal and contributing factors, and the effectiveness of risk reduction measures. The preliminary objective was *to describe and to estimate* these factors.
2. A formal risk assessment will use quantitative methodologies and risk assessment tools. The preliminary risk assessment relied on your own judgment and the judgment of local experts in your preliminary assessment.

Specific differences in approach will include the following:

GATHERING INFORMATION: STEPS 1 THROUGH 3

These steps are similar in both a preliminary and in a formal risk assessment. Since a formal assessment will provide quantitative results, the data search of a risk assessment team should be more extensive than yours. Similarly, if they use expert judgment, the should have some method of validating and scaling what the experts tell them. You may find that risk analysts are comfortable in crunching numbers from easily obtainable data bases such as the Coast Guard marine safety data and the Corps of Engineers Waterborne Commerce. They are often less comfortable about seeking local data sources and may not wish to interview local experts. You should ensure that they do both, otherwise their product will not be acceptable to many stakeholders.

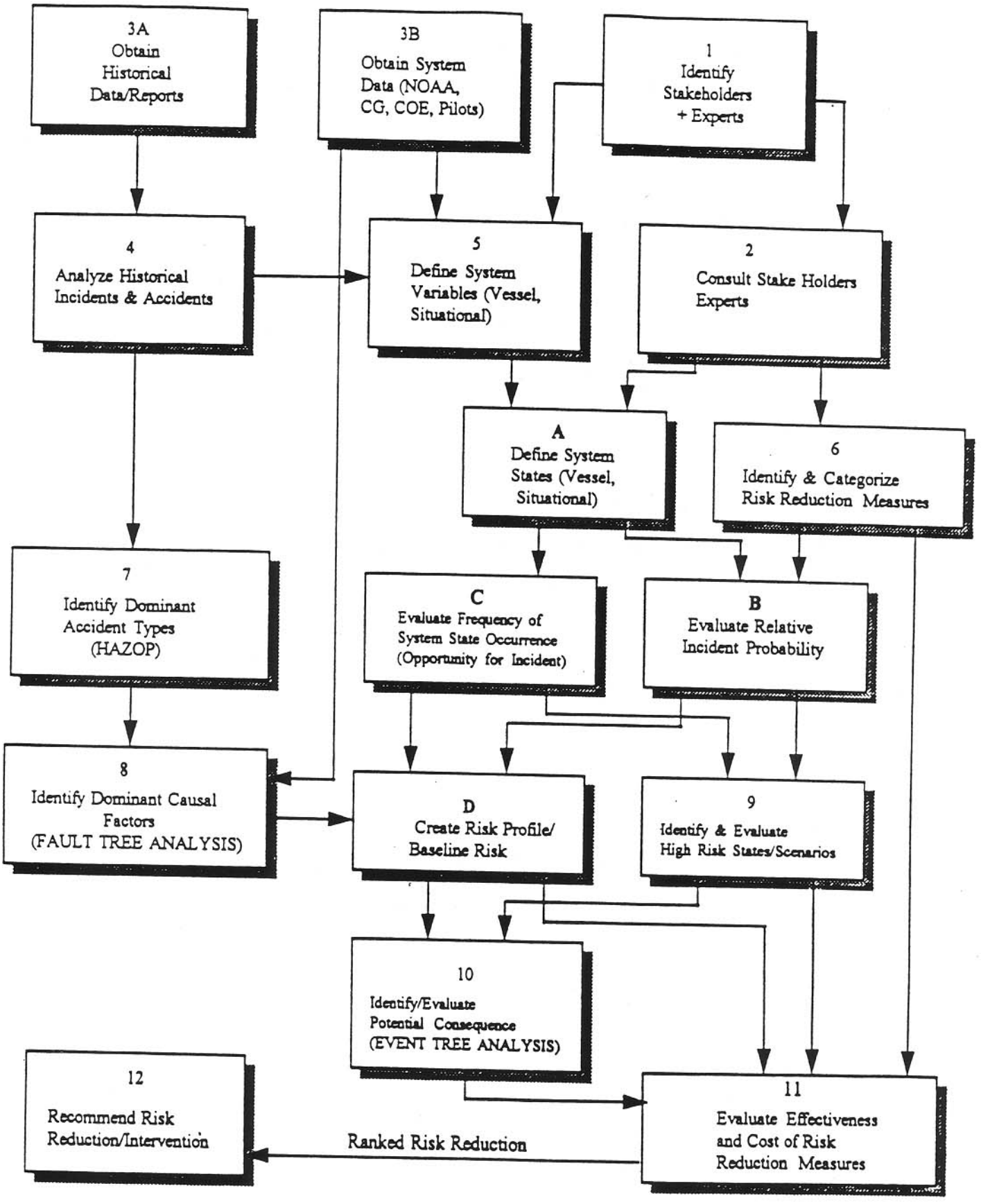


Figure A-3 : Flow Chart - Formal Risk Assessment

FRAMING THE RISK ASSESSMENT: STEPS 4,5,6

In a formal risk assessment, a full causal analysis should be conducted for all relevant historical accidents in your area (Step 4). The vessel traffic data and environmental data that you estimated in step 5 should be obtained by the risk assessment team as the basis for their quantitative analysis.

THE EVALUATION OF RISK: STEPS, 7,8, A, B C, D 9 AND 10

This is where a full risk assessment will diverge most significantly from your preliminary assessment. There is not a uniformly accepted risk assessment methodology for application to ports and waterways so different consultants and analysts will use different methodologies and tools. Steps 7 and 8, the identification of dominant accident types and causal factors may involve fault tree models or other probabilistic risk assessment methods, statistical models, regression analysis, or a functional flow analysis. If the analysts perform an analysis of the contributing system states, they should complete the following additional steps:

Step A: Define possible system states in terms of vessel and situation attributes

Step B: Estimate the relative probability of an accident for each system state based on historical data analysis or expert judgment.

Step C: Evaluate the frequency of occurrence of system states. This evaluation of risk exposure will require a statistical analysis of historical data or a simulation.

Regardless of the methodology used by the risk analysts, the following steps must be completed:

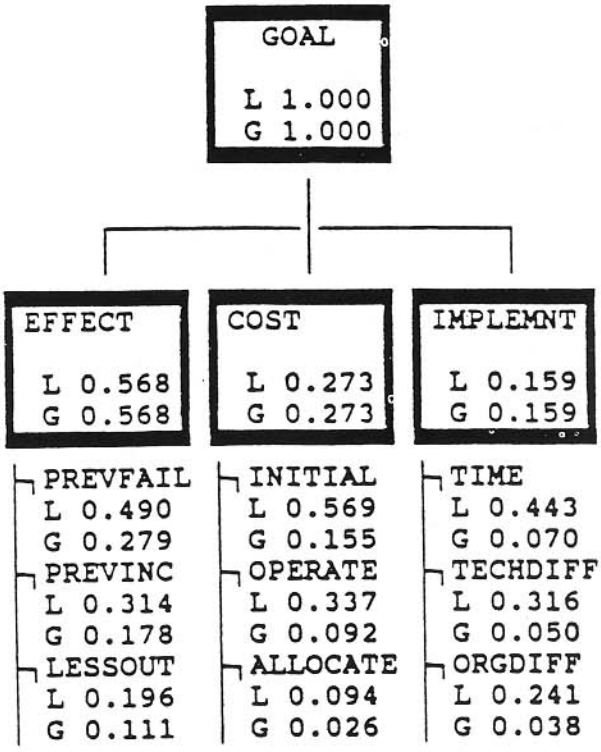
Step D: Evaluate the baseline risk of the system and create a risk profile. This baseline risk will be used to evaluate all potential changes to the system.

Step 9 Identify *and evaluate* high risk states and scenarios. This activity is similar to the that completed in a preliminary risk analysis, except that the risk of high risk states and scenarios is quantitatively evaluated.

RISK REDUCTION EVALUATION and RISK MANAGEMENT: STEPS 11 AND 12

The process of evaluating risk reduction measures and recommending risk interventions in a formal risk assessment follows essentially the same logical process used in a preliminary risk assessment. The significant difference is that the quantitative models used to calculate the baseline risk are also used to estimate the effect of proposed risk reduction measures. Decision analysis methodologies such as multi attribute utility analysis or the analytic hierarchy process will be used to develop risk management recommendations. Figure A-4, for example, shows a multi-attribute risk reduction measure evaluation hierarchy constructed using the analytic hierarchy process (AHP) that could be used to evaluate proposed risk reduction measures. In this model the primary factors considered are EFFECTIVENESS (as measured in the effect on lowering baseline risk), COST (the economic cost of the measure), and IMPLEMENTATION (ease of implementation. In the model shown, 70% of the weight is given to the effectiveness factor, 20% to the cost factor, and 10% to the implementation factor. Each factor may be subdivided until a level convenient for comparison purposes is reached. In the example provided, EFFECTIVENESS is subdivided into the effectiveness in preventing an error or failure (e.g. inspection and training programs), effectiveness in preventing an accident once an error or failure incident has occurred (e.g. VTS), and effectiveness in minimizing the consequences once an accident has occurred (e.g. fire and rescue boats). COST is sub divided into the elements of initial cost, operating cost, and cost allocation (who pays the cost). IMPLEMENTATION has the sub elements: time required to implement, technical difficulty, and organizational/political difficulty

GOAL: TO RANK RISK REDUCTION MEASURES



EFFECT --- RISK REDUCTION EFFECTIVENESS (% REDUCTION IN EXPECTED SPILL VOLUME)
- PREVFAIL --- EFFECTIVNESS IN PREVENTION OF ERROR OR FAILURE
- PREVINC --- EFFECTIVENESS IN PREVENTING INCIDENT GIVEN FAILURE OCCURS
- LESSOUT --- LESSEN EFFECT OF UNDESIRABLE OUTCOMES OF INCIDENT

COST --- ECONOMIC COST OF MEASURE
- INITIAL --- INITIAL INVESTMENT COST
- OPERATE --- ANNUAL OPERATING COST
- ALLOCATE --- ALLOCATION OF COSTS

IMPLEMNT --- EASE OF IMPLEMENTATION
- TIME --- TIME REQUIRED TO IMPLEMENT
- TECHDIFF --- TECHNICAL DIFFICULTY OF IMPLEMENTING
- ORGDIFF --- ORGANIZATIONAL AND POLITICAL DIFFICULTY

L --- LOCAL PRIORITY: PRIORITY RELATIVE TO PARENT
G --- GLOBAL PRIORITY: PRIORITY RELATIVE TO GOAL

FIGURE A-4

WORKSHEET 1

STAKEHOLDER IDENTIFICATION

STAKEHOLDER NAME	STAKEHOLDER TYPE (GOVT AGENCY, BUSINESS, NOT FOR PROFIT, PROF, ASSOC., ADVOCACY GROUP, INDIVIDUAL)	AREAS OF STAKEHOLDER INTEREST AND CONCERN	AREAS OF STAKEHOLDER EXPERTISE	STAKEHOLDER RELATIONSHIP WITH THE COAST GUARD

WORKSHEET 2A: U.S. VESSEL RISK FACTORS

	ANNUAL TRAFFIC SUMMARY		VESSEL ATTRIBUTE HIGH RISK VALUES				
	1	2	3	4	5	6	7
VESSEL TYPE	NUMBER OF VESSELS	NUMBER OF TRANSITS	VESSEL AGE AGE >25 YEARS	CLASSIFICATION SOCIETY NOT INSPECTED/ NOTCLASSED BY RECOGNIZED CLASS SOCIETY	PILOT STATUS NO PILOT ON BOARD	MANAGEMENT AND OWNERSHIP FREQUENT CHANGES OR TARGETED OWNER	VESSEL VIOLATION & ACCIDENT HIST REPEATED MINOR OR RECENT MAJOR
DEEP DRAFT CALLING FLEET							
CONTAINER VESSELS							
PASSENGER VESSELS							
SPECIAL PURPOSE VSLS.							
TANK VESSELS							
BULK CARGO VESSELS							
OTHER							
SHALLOW DRAFT TRANSIT FLEET							
INLAND PASSENGER VSLS							
FISHING VESSELS							
TUGS WITH TOWS							
LINE HAUL TOWS							
OTHER							
SHALLOW DRAFT LOCAL FLEET							
FERRIES							
EXCURSION BOATS							
GAMBLING BOATS							
OTHER							

INSTRUCTIONS: In column 1, enter the number of vessels of each type operating in port during last year (source COE). In column 2 enter the number of transits for each vessel type
In columns 3 through 8, enter the % of vessels for each type that can be described by the high risk value indicated for each attribute

WORKSHEET 2B: FOREIGN FLAG VESSEL RISK FACTORS

	ANNUAL TRAFFIC SUMMARY		VESSEL ATTRIBUTE HIGH RISK VALUES			
	1	2	3	4	5	6
VESSEL TYPE	NUMBER OF VESSELS	NUMBER OF TRANSITS	PRIORITY I VESSELS	PRIORITY II VESSELS	PRIORITY III VESSELS	PRIORITY IV VESSELS
DEEP DRAFT CALLING FLEET						
CONTAINER VESSELS						
PASSENGER VESSELS						
SPECIAL PURPOSE VSLS.						
TANK VESSELS						
BULK CARGO VESSELS						
OTHER						
SHALLOW DRAFT TRANSIT FLEET						
INLAND PASSENGER VSLS						
FISHING VESSELS						
TUGS WITH TOWS						
LINE HAUL TOWS						
OTHER						
SHALLOW DRAFT LOCAL FLEET						
FERRIES						
EXCURSION BOATS						
GAMBLING BOATS						
OTHER						

INSTRUCTIONS: In column 1, enter the number of vessels of each type operating in port during last year (source COE). In column 2 enter the number of transits for each vessel type In columns 3 through 8, enter the % of vessels for each type that can be described by the high risk value indicated for each attribute

WORK SHEET 3: WATERWAY SYSTEM RISK FACTORS

	SYSTEM VARIABLE HIGHEST RISK VALUE						
	1	2	3	4	5	6	7
WATERWAY CONFIGURATION	PERCENTAGE OF WATERWAY OR PORT AREA	VISIBILITY **RESTRICTED/ RAPIDLY CHANGING**	WIND **HIGH OR RAPIDLY CHANGING**	CURRENT **HIGH/ RAPIDLY CHANGING**	RIVER STAGE **HIGH/RAPIDLY CHANGING**	TRAFFIC SITUATION **COMPLEX**	TRAFFIC DENSITY **MULTIPLE VESSELS**
OPEN WATERWAY							
RESTRICTED WATERWAY							
CONVERGING WATERWAY							

INSTRUCTIONS:

In column 1 enter the approximate percentage of the waterway or port area for each waterway configuration.
An open water way is a clear fairway with good water on both sides of the channel.
A restricted waterway is a waterway with shallow water or other hazards close to the marked channel,
and a converging waterway has multiple channels that meet or cross.

In columns 2 through 7 enter the approximate percentage of time that the worst case conditions indicated exist in the port.
Precise definitions for terms like "restricted", "difficult", "high", and "complex" vary from port to port and must be determined prior to completing this work sheet.
Suggested sources of information: Coast Pilot, NOAA, COE (for river stage, and current).

WORKSHEET 4

CATEGORIZATION OF RISK REDUCTION MEASURES

TYPE OF INTERVENTION	EFFECT OF INTERVENTION		
	TO PREVENT THE OCCURRENCE OF ERRORS, FAILURES OR UNSAFE CONDITIONS THAT COULD LEAD TO AND ACCIDENT	TO PREVENT THE OCCURRENCE OF ACCIDENTS RESULTING FROM FAILURES, ERRORS OR UNSAFE CONDITIONS	TO MINIMIZE THE CONSEQUENCES OF AN ACCIDENT
WATERWAYS MANAGEMENT AND TRAFFIC CONTROL			
VESSEL PERSONNEL AND PILOTAGE			
VESSEL EQUIPMENT AND DESIGN			
INSPECTION AND ENFORCEMENT			
EMERGENCY OPERATIONS AND PROCEDURES			
OTHER			

WORKSHEET 5

DESCRIPTION OF HIGH RISK STATES/SCENARIOS AND POTENTIAL CONSEQUENCES

1	2	3	4	5
DOMINANT ACCIDENT TYPE (STEP 7	VESSEL RISK STATE (STEPS 5 & 9, WS 2)	SITUATIONAL RISK STATE (STEPS 5 & 9, WS 3)	RISK SCENARIO (STEPS 7,8,9)	POTENTIAL CONSEQUENCES (STEP 10)

In column 1, list dominant accident types from Step 7.

In columns 2 and 3, indicate the high risk vessels and/or the high risk situations that would make the accident more likely

In column 4, indicate a dominant, or likely, causal scenario that could lead to the accident

In column 5, indicate the potential consequences of the accident