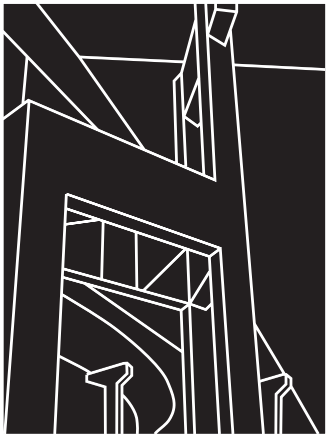
RESEARCH REPORT 1833-2

AN IDENTIFICATION PROCESS AND EVALUATION FRAMEWORK FOR TEXAS GULF CONTAINERSHIPS

Michael Bomba and Robert Harrison



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16. Abstract

This is the second in a series of four reports prepared by the Center for Transportation Research at The University of Texas at Austin for the Texas Department of Transportation to explore containership activity in the Gulf of Mexico. The original scope of work for this report was to produce a process for selecting a candidate port to become a containership load center among Texas Gulf ports. As the project progressed, however, the scope was expanded to also provide a port evaluation process that would be useful to all Texas ports that might provide containership service. The report begins by identifying and discussing relevant topics of port development and operations in four general areas: infrastructure demands; environmental constraints; locational attraction and landside access; and port finance. After introducing the issues surrounding these topics, the report proposes a load center selection process and a containerport evaluation process. The procedure for constructing a load center selection process concentrates on the following: heuristic methods; selecting matrix parameters; parameter criteria; and the scoring and weighting of these parameters and criteria. The port evaluation process focuses on identifying baseline characteristics, determining objectives and alternatives, assessing these objectives and alternatives, and identifying a preferred alternative and its constraints. In its conclusion, the report recommends that these techniques be reviewed and tested on selected Texas ports and that the data collected for the project's decision tools be stored and updated in a database for TxDOT's future use.

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by

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and
Robert Harrison

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U.S. Department of Transportation, Federal Highway Administration.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE
INTRODUCTION

PROJECT BACKGROUND

Late in 1998, the Texas Department of Transportation (TxDOT), represented by its Transportation Planning and Programming (TPP) Division, commissioned the Center for Transportation Research (CTR) at The University of Texas at Austin to examine infrastructure impacts and operational requirements associated with the large containerships known as *mega-containerships*. The research project was designed with two primary goals in mind. First, the project was to address the planning, institutional, and financial issues associated with increased containerized freight traffic. The second goal was to assess the demand on the multimodal transportation system in Texas, contingent on the operation of these large containerships in the Gulf of Mexico. The first deliverable of the project, *Mega-Containerships and Mega-Containerports in the Gulf of Mexico: A Literature Review and Annotated Bibliography* (1833-1), was a review of mega-containership literature. This report is the second deliverable, which was originally intended to create a process for selecting a candidate port to become a mega-containership load center in Texas. However, for reasons discussed in the section below, the purpose of this report was expanded to include an evaluation process useful to all Texas ports. This document will be followed by a third deliverable, which will forecast the international demand for container traffic in the Gulf. The fourth and final report will concentrate on landside access issues and will produce a modal split model to predict container movements to and from Texas ports.

PROJECT PURPOSE

The planning process for any transportation infrastructure project requires multiple steps in which project planners start at the most general level of study and methodically work their way down to detailed plans and analyses. Figure 1.1 shows a general overview of this process. Government or private entities first informally identify the problems of existing infrastructure, then propose ideas for solving these problems. If there is a commitment among the stakeholders, these informal discussions are usually followed by more detailed feasibility studies. Feasibility studies seek to determine the reasonableness of a proposition and whether it has any “fatal flaws.” If a project is found to be “reasonable” and there are no fatal flaws, then public transportation projects involving the use of federal funding must follow a strict legalistic process, which often requires performing a Major Investment Study (MIS). An MIS is a preliminary planning document that sets forth the purpose and need for a project and, in addition to the original proposition, discusses a wide range of alternatives to reach the same goal. Projects then move into more rigorous and detailed analyses when planners conduct an Environmental Assessment (EA) or an Environmental Impact Statement (EIS). Alongside the environmental studies and beyond their completion, project engineers perform cost-benefit analyses, forecast usage of the proposed facility, and create detailed schematic designs for the proposed project. It is at this stage of the process that port operators become concerned with issues at the detailed operational level, such as the width of a port’s entrance gate. Upon completion of the daunting regulatory framework and the project’s engineering tasks, the process enters into the difficult phase of funding acquisition. The funding process is often located in the political sphere, taking place well beyond the direct influence of the port planners and engineers. Finally, after the project secures funding, construction begins, and ultimately the facility begins its operations.

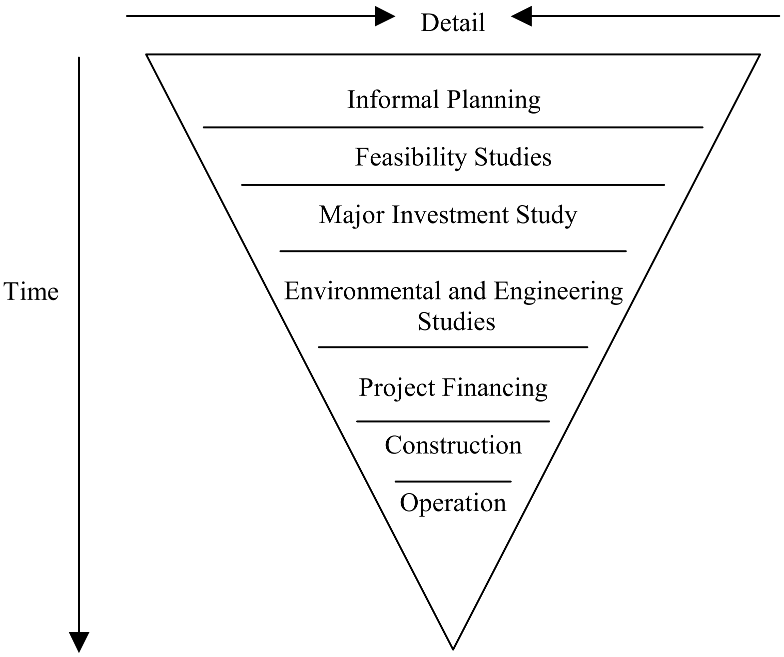

Figure 1.1. A General Overview of the Transportation Infrastructure Planning Process

This project fits within the range of feasibility studies shown in Figure 1.1 and prepares ports for moving into the MIS stage, if required. The original intent of this report was to create an identification process for choosing a mega-containership load center in Texas among its existing ports. However, the international demand analysis (Research Report 1833-3) provides no evidence that a mega-containership load center is currently feasible in Texas or in the foreseeable future. In light of these findings, the original intent of the project appeared to have little immediate purpose. Despite the lack of immediate need, there are reasons for moving forward with the creation of the identification process. First, predicting the activity of the shipping industry is difficult, owing to its dynamic nature. Conclusions drawn today from reasonable assumptions and analyses can quickly become outdated if unexpected changes occur in the shipping industry or in global trade. Thus, while it does not appear at present that a mega-containership load center in Texas is feasible, it is possible that events could occur that would require a reassessment of this position. Second, the time required between the informal planning stage of a major transportation infrastructure project and the operation stage can easily reach 20 to 30 years. Therefore, while the project does not appear to be immediately feasible, it makes sense to produce a general framework should a mega-containership load center become desirable in the future.

Even if a Texas port does not become a North Atlantic load center, a load center located in one of the two more likely locations (namely Freeport, Bahamas; or Panama City, Panama) would bring about changes in the routes of many containerships, especially those ships from Europe entering the Gulf. In the future, ports may see spoke routes radiating from a North Atlantic load center; these spoke routes could include calls on ports that do not regularly service containerships. When informed of the findings of the international demand analysis, representatives from TxDOT decided that the efforts of this project would be better directed to providing information to all Texas port operators. Because TxDOT has an interest in improving highway access and connectivity to all marine sites, a general containerport evaluation process was developed along with the load center identification process. CTR has thus produced a process that allows each Texas port authority to evaluate its existing facilities and to determine (1) which improvements and issues to be considered in order to service larger containerships or (2) whether the port authority plans to host containerships at all.

PROJECT GOALS

The selection and evaluation processes of this project had several goals, which included establishing a sound foundation both in pragmatism and theory, fairness, relevance, and accessibility. While a pragmatic view of port development is useful, it offers no consistent structure. The inclusion of current research material creates a report context richer than one that simply provided anecdotal evidence and port dimensions. As a selection matrix, the report sought to create a tool that would use reasonable criteria and be viewed as fair by all involved parties (i.e., the evaluators and those being evaluated). As an evaluation tool, the report, using relevant information, provides a methodical procedure that ports considering facility improvements might follow. Both goals were pursued through an extensive review of the literature related to port development — a review that sought to include as many criteria as possible. Finally, the selection matrix and evaluation processes were designed so that they would be easily understandable. While an approach could have been designed that used sophisticated statistical techniques or some other advanced quantitative methods, it was decided that the identification and evaluation processes should require no special understanding of mathematical techniques. The planning process would be of little use if it were designed in a manner that constrained maximum participation by TxDOT, port operators, local transportation planners, and knowledgeable members of the public.

REPORT OUTLINE

The next four chapters of this report provide a narrative of the major issues surrounding port planning and development. The intent of these chapters is to provide not only background information, but also a justification for the criteria later used in the identification and evaluation processes. Chapter Two examines the infrastructure demands of ports, while Chapter Three surveys some of the environmental laws and issues pertaining to port construction and operation. Chapter Four discusses the characteristics of regional demand (called locational attraction) and landside access, while Chapter Five identifies some of the financial issues that port authorities encounter. Chapter Six presents the original identification matrix, and Chapter Seven outlines the conversion of the identification matrix into an evaluation technique. It should be pointed out that this report fulfills both the original scope of work for the project, providing as it does a mega-containership load center identification process, and the project's expanded scope of work. Finally, Chapter Eight summarizes the report and makes recommendations.

CHAPTER TWO
INFRASTRUCTURE DEMANDS

INTRODUCTION

This chapter briefly reviews some of the infrastructure requirements of a port from the time a container enters by ship, truck, or train until the time that container departs for its next destination using a different mode. The chapter discusses channel depth, channel width, maneuverability requirements, and harbor configurations. It also examines the dockside infrastructure required for a containerport—specifically cranes, dockside container moving equipment, rail infrastructure, and acreage and warehouses. Optimal port characteristics often depend on both local circumstances and the desired and realistic expectations of port demand. Since there are many possible outcomes, one must expect different restrictions, permitting requirements, and goals during the planning process. The purpose of examining these nautical and dockside aspects is to make clear not only the current capacities of Texas ports, but also their abilities and deficiencies in serving containerships.[1]

Chadwin et al. (1990) posit that any legitimate containership port must perform four functions, namely, the receiving, storing, staging, and loading of containers. The receiving of containers can be either those containers arriving at the terminal for import (via ship) or those for export (via truck or rail). Another component of the receiving function is the "capture" of information about the container (e.g., its contents and destination). The storage function is the placing of a container, after it has been received, at a known and recorded location so port operators can find the container when needed. Staging involves preparing a container to be moved, either to a departing ship or to a departing truck or train. Finally, the loading stage occurs when a container is placed upon another mode of transportation to its next destination. Correct information is especially important at this stage, since a container shipped to a wrong location could take weeks to return (Chadwin et al., 21–22).[2]

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[1] For a more detailed discussion of the infrastructure necessary for a Class V ship load center, see Report 1833-1, *Mega-Containerships and Mega-Containerports in the Gulf of Mexico: A Literature Review and Annotated Bibliography.*

[2] Chadwin et al. (1990) provide a very good discussion of port operations and efficiencies that warrants review. Their discussion is significantly more detailed than that provided in this short narrative.

NAUTICAL INFRASTRUCTURE

Approach Channel Depth and Width

The depth of the approach channel is perhaps the most critical element of any port's design, since the deepening and widening of a channel is the most expensive and regulated component of port improvement. Channel characteristics are particularly important for ports wishing to serve Class V ships, since a load center would require a 50-foot channel draft. This 50-foot figure includes a 46-foot draft for the ships when fully loaded, with an additional 2-foot leeway for vertical ship movement and 2 feet for under-keel clearance. This figure is significant, since very few ports in the U.S. have the required channel depth to become a load center. The only other option for a port with insufficient channel depth wishing to serve the largest ships is to require the ships to enter the port when they are not fully loaded. This means that the port would not be the ship's first call, but rather its second (or later) call. Whether this is a realistic solution for ports unable to pursue further dredging is unclear, since it may not be economically feasible for ship operators, owing to the high fixed and variable operating costs of a Class V ship. With regard to channel width, a Class V ship, according to VZM/TranSystems, must have an 800- to 1,000-foot-wide channel. As a general rule for all containerships, "the nominal [channel] width should not be smaller than 5 times the beam of the largest vessel..." (Bruun 209). Other channel issues to consider are how tide levels alter a channel's depth, one-way versus two-way traffic, and the effects of wave swells (Bruun 206).

Deepening and widening a channel means dredging, which leads to high costs and to a number of environmental regulations for port operators to consider. Dredging projects require extensive coordination with the U.S. Army Corps of Engineers, including detailed studies on the effects of dredging. Additionally, the costs of dredging are significant, and most projects are funded largely by the federal government with contributions from local entities. However, given the magnitude of many projects, even a "small" contribution is a significant obstacle for many local governments. The environmental problems associated with dredging—the largest issue of which involves the disposal of spoil, particularly when the spoil materials are contaminated—will be covered in greater detail in a later section of this report.

Channel Layout, Maneuvering

One characteristic of a port is the layout and the maneuverability of its turning basin. The turning basin is a circular area of the port used by ships to turn around in order to leave the harbor. Ships may turn around in the basin either independently or with the assistance of a tugboat, the need for which is determined by the radius of the turning basin. The smaller the radius, the less likely it is that a ship will be able to complete the turn under its own power. The suggested diameter of a turning basin for a Class V ship is between 1,430 and 1,650 feet (VZM/TransSystems). The United Nations makes the more general recommendation that the diameter of the turning basin be 3 times the length of the longest ship to enter the port (United Nations, 77). Another component of maneuverability is the vessel's stopping distance. Two ways in which a port can provide adequate stopping distance for ships are to either lengthen the distance of the channel (allowing an adequate distance for the ship to come to a safe stop) or to implement a "speed limit" at the port's entrance. The latter of the two is obviously the more cost-effective method.

Berth and Harbor Configurations

Harbor configuration is the manner in which the berthing docks of a port are positioned and aligned. Port authorities have several options for the configuration of their harbor, and each of these options has its own advantages and disadvantages affecting the port's ability to serve different types of ships. Most importantly, a port should be able to service several ships of all sizes at once. Beyond this requirement, available land and sea area are two important factors to consider when planning a port's configurations. The land area available to a port must be sufficient to handle several of the key operations for loading and unloading a ship. The port property must be large enough to house the massive cranes necessary to unload the vessels. Additionally, there must be space—a *staging area*—immediately behind the cranes for placing large containers after their unloading. The staging area must be free of obstructions (e.g., storage, maintenance, or administrative buildings) so that it is possible to quickly and efficiently move the containers to the storage area (Chadwin et al., 23). The constraints of limited sea area are obvious; with more sea area, it is possible to have more docking areas, thereby expediting trade by eliminating "traffic" at port entrances.

Straight, herringbone, "T," finger piers, and slip piers are examples of different layouts found in ports around the world. Straight, herringbone, and "T" piers are simple layouts (see Figure 2.1). Each consists of a single pier, the length and width individual to each. The straight pier is either perpendicular or parallel to the shoreline, whereas the herringbone is at an angle that minimizes ship maneuvering. While simple and flexible, the ability of the herringbone configuration to service mega-containerships or many other types of vessels may be inadequate because it provides little land contact. A "T" pier is similar to the straight and the herringbone piers in that only one side of the vessel is in contact with the piers (see Figure 2.1.d). The design is simple: The pier extends into the water and at the end a perpendicular pier is constructed. The advantage of the "T" pier is its ability to service more ships than the straight or herringbone. However, these types of piers are often narrow, leaving less room for the necessary cargo handling equipment and staging facilities.

a.) Straight *b.) Straight* *c.) Herringbone* *d.) "T"*

Figure 2.1. Straight, Herringbone, and "T" Pier Layouts

Finger piers, as shown in Figure 2.2, further increase the number of ships that can be serviced within a given area. Again, as with the "T" pier, the finger layout decreases the amount of land for equipment and facilities. Also, with a greater number of berths, there is less area allowed for each ship. The final type of pier, the slip pier (shown in Figure 2.3), is similar to the herringbone pier, but instead of the ship contacting land only on one side, the end of the ship enters an enclosure of land. Depending on the design, a ship might be almost entirely surrounded by land, which could allow for quicker unloading, primarily because the ship could be unloaded from both sides rather than from only one side. For some ports, this layout might eliminate the need for costly new cranes, since it would not require that a port's cranes have an outreach that spans an entire ship's width.

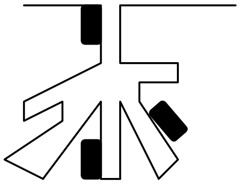

Figure 2.2. Finger Configuration

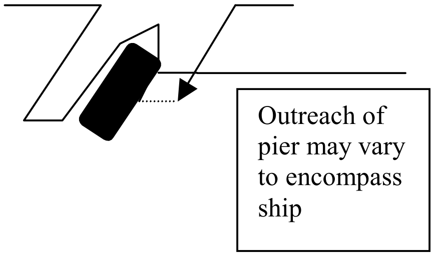

Figure 2.3. Slip

DOCKSIDE INFRASTRUCTURE

Cranes and Container Yard Moving Equipment

When containerization first began, containers were lifted on and off ships by cranes mounted on the ship's deck. As containers became heavier, however, ships could not maintain an even keel during use of these onboard cranes, and it was consequently necessary to mount them on shore. The most commonly used container crane today is the gantry crane, which is built like a bridge with a trestle at each end. The crane's boom reaches out horizontally over the ship and lowers a spreader, which mounts itself to the container for lifting. Because containers are of different sizes, the spreader moves its connectors inward or outward to the appropriate width so the connectors can attach to the box for lifting. Crane size and outreach have grown as ship sizes have increased. When the largest ships built could still fit through the Panama Canal, manufacturers built cranes to reach out approximately 125 feet (the Canal's width limitation is 105 feet). Now that the Panama Canal's width is no longer used as a ship parameter, cranes are being constructed with outreaches of more than 200 feet and are capable of serving containerships larger than those that currently exist. Cranes are also being made to lift heavier loads, since 47- and 53-foot containers have come into use, and cranes are taller because of larger ships and higher stacks of containers. Container cranes have become quite expensive, and those capable of serving Class V ships may cost more than \$8 million, while smaller cranes serving third-generation Post-Panamax ships cost between \$5 and \$8 million (Muller, 230–234).

A number of different pieces of equipment are used to move containers about the storage and staging areas of a dock (before and after the containers are lifted from a ship). Commonly used pieces of equipment include a chassis system, straddle carriers, yard gantry cranes, forklift trucks, and container handlers. Table 2.1 summarizes the characteristics of these pieces of equipment.

Chassis systems move containers from a port's staging area to its storage area. After lifting a container off a ship, cranes place the container on a trailer chassis (called the container chassis), which is hauled by a yardhorse. A yardhorse is basically a small, minimally equipped truck (e.g., small operator cab). After a container is placed on the chassis system, it can be hauled to its temporary storage location on the dock to be lifted and stored by another piece of container-moving equipment, or it can simply be left on the chassis (Muller, 236–237).

A similarly functioning, but much larger, machine is the straddle carrier. A straddle carrier lifts and holds containers in an under-slung fashion as it transfers containers to or from the crane or to a truck or rail car. Some straddle carriers now being produced can lift containers stacked four high, giving these carriers greater capacity. One downside to straddle carriers, however, is that they are difficult to maneuver, especially when there is considerable dockside traffic. In fact, there have been instances in which straddle carriers, operating at unsafe speeds, have tipped over. Because straddle carriers are useful only for lifting heavy loads at a minimal height for short-distance travel, they work best in medium- to smaller-sized terminal operations (Muller, 231–233).

Rubber tire gantries (RTGs), also called stacking cranes, carry and stack containers in an under-slung fashion (like the straddle carrier) and are found at most new terminals. However, an RTG is built wider than the straddle carrier, so it can stack up to six containers directly against each other. The RTG's appearance is similar to that of a section of bridge mounted on tires, with a spreader hanging from below. One of the RTG's advantages, in addition to its efficiency and ability to stack containers very densely, is that it can be automated so that no operator is required. A disadvantage of the RTG is its limited mobility. Wider stacking cranes, among them the Transtainers™, are also coming into use. Transtainers can work with containers stacked five to seven wide while also loading rail and truck chassis; they have, however, proved to be expensive to purchase and maintain (Muller, 233–234).

A "forklift truck" is a generic term for an entire group of container-handling equipment. These forklifts can raise 20-foot containers weighing 28 tons and 40-foot containers weighing 42 tons. They can also be fitted to lift three stacked and fully loaded containers at one time or five stacked and empty containers at once. Container handlers differ from forklifts in that they raise containers from the top, rather than from below. They are becoming popular for use at container terminals because they possess an overreach capability that forklifts do not have (Muller, 234–235).

Table 2.1. Summary of Dockside Container Handling Equipment (Excluding Cranes)

Activity	**Chassis System**	**Straddle Carrier**	**Rubber Tire Gantry (RTG)**	**Forklifts and Container Handlers**
Land Area[1]	70 TEUs per acre 173 per hectare	168 TEUs per acre 413 per hectare	325 TEUs per acre 802 per hectare	240 TEUs per acre 590 per hectare
Cost of terminal development	Low	Medium	High	Medium to high
Cost of equipment	Tractor $60,000 Chassis $12,000	$1,000,000	$1,250,000	$500,000 to $700,000
Support equipment per container crane	4 to 5 tractors, 1 chassis per tractor	3 to 4	1 to 2 cranes, 5 tractors and chassis	2 such as RTG
Operating labor	Low	Low	Medium to high	Medium
Equipment maintenance	Low	High	Medium	Medium
Inventory control	Good, but frequent yard checks required	Good, but frequent yard checks required	Very good	Good
Advantages	High accessibility; low-cost equipment; low pavement expense	Versatility; less support equipment needed; high pavement costs	Low maintenance; good control; expandable system; high pavement costs	Versatility; low maintenance; high pavement costs
Disadvantages	High land requirements; large chassis requirements	High damage and maintenance costs; low visibility for operators; oil leaks from hydraulic systems	Initial equipment and land preparation cost	Slower productivity compared to other equipment
Security	Excellent	Good	Poor	Good
Damage	Minimal (0–1%)	High (3–5%)	Medium (2%)	High (3–5%)

[1] Container productivity per land area is expressed in 20-foot equivalent units (TEUs).

Original source: Captain Warren H. Atkins, Modern Marine Terminal Operations and Management. San Francisco, CA: The Port of Oakland, California, The Compage Company, 1983, p. 45; and updating from several other sources, including Capt. Fiaz Ahrein, Professor, U.S. Merchant Marine Academy, Kings Point.

Reproduced from: Gerhardt Muller. Intermodal Freight Transportation, 4th ed. Washington, D.C.: Eno Transportation Foundation and Intermodal Association of North America, 1999, p. 238.

RAIL INFRASTRUCTURE

Port rail infrastructure usually exists in one of three forms, all of which possess varying degrees of efficiency and flexibility. In one form, rail infrastructure does not exist at the port itself but rather at a container terminal located some distance away. In these instances, it is necessary for containers to be carried from the port to the rail terminal by truck. This requirement often means that a container experiences several additional moves from its landside origin point to its eventual point of departure. In a second form of rail infrastructure, the rail terminal lies within the port, though it is not located along the dock. In these cases, it is still necessary to move the container about the staging and storage area before eventually placing it on a train. Finally, the most efficient form of rail access is a scheme whereby the track runs directly along the terminal's berth, so that a crane can place the container directly on the rail car. Very few ports in the U.S. have this configuration, as its ability to serve only a short length of train renders it somewhat limiting. Generally, because the cost of providing direct rail access to ports is high, many rail carriers are reluctant to make the necessary infrastructure investment, thus placing the burden of rail access squarely on the ports.

ACREAGE AND BUILDINGS

Acreage and building requirements of a port depend largely on the volume of its container throughput. The average container terminal throughput ranges from 30,000 to 500,000 20-foot equivalent units (TEUs) in a year, and most ports handle between 2,000 and 4,000 container moves per acre (Muller 1999, 219). Most large U.S. ports have a container terminal that is between 100 and 200 acres in size. Ports with larger container volumes need more acreage, but in areas with high land costs, like Hong Kong, special buildings have been used to store more containers within a smaller tract of land (Muller 1999, 225).

In addition to its berth, staging, and storage areas, a port needs acreage for administrative offices, equipment maintenance and repair, receiving and delivering canopies, and facilities for its many other daily functions.

CHAPTER THREE
ENVIRONMENTAL CONSTRAINTS

INTRODUCTION

Table 3.1 shows the many federal environmental laws relevant to port operations and construction.[3] For the purpose of the evaluation and identification processes, the environmental parameter was divided into three broad categories: ecological, air and water, and human. The ecological issues addressed included a port's effect on endangered species, along with its impacts on sensitive aquatic and terrestrial habitats. The air and water criteria concentrated on the following effects: ambient air quality (ozone), water pollution, and dredging (sediment contamination and the encroachment of salt water into fresh water bodies). Finally, issues concerning human environments included land use changes, the effects of port operations and construction on surrounding communities, changes to the ambient noise level, and the impacts on archeological and historical sites within a port's operational area (both terrestrial and submerged).

There are many more issues of environmental concern than could be presented here. Accordingly, this discussion will not seek to represent a comprehensive review of these issues or their regulatory framework. A more comprehensive review of the impacts created by port construction and improvements would, in any event, occur later in the planning process and, at that time, an MIS and/or EIS would be required before construction could begin. Thus, the following paragraphs are intended to demonstrate the importance of each criterion within the environmental parameter.

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[3] The EPA publishes *Profile of the Water Transportation Industry*, an excellent overview of federal environmental laws and regulations related to port activities.

Table 3.1. Federal Environmental Laws Relevant to Port Construction and Operation

Act to Prevent Pollution from Ships (APAA) (33 USC 1901–1911)
Asbestos Hazard Emergency Response Act (15 USC 2641–2656)
Clean Air Act (CAA) (42 USC 2071–2297)
Clean Water Act (CWA) (33 USC 1251–1387)
Coastal Zone Management Act (CZMA) (16 USC 1451–1465)
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (including the Superfund Amendments and Reauthorization Act of 1986) (42 USC 9601-9675)
Emergency Planning and Community Right-To-Know (EPCRA) (42 USC 11001–11050)
Endangered Species Act (ESA) (16 USC 1531–1543)
Federal Insecticide, Fungicide and Rodenticide Act (7 USC 1362–1364)
Fish and Wildlife Coordination Act (FWCA) (16 USC 661–666c)
Marine Protection Research and Sanctuaries Act (MPRSA) (33 USC 1402–1455)
Medical Waste Tracking Act (42 USC 6903)
National Environmental Policy Act (NEPA) (42 USC 4321–4370d)
Nonindigenous Aquatic Nuisance Prevention and Control Act (16 USC 4701–4751)
Occupational Safety and Health Act of 1970 (OSHA) (29 USC 651–678)
Oil Pollution Act of 1990 (OPA) (42 USC 2701–2761)
Pollution Prevention Act of 1990 (42 USC 13101–13109)
Ports and Waterways Safety Act (RCRA) (42 USC 1221–1232)
Resource Conservation and Recovery Act (RCRA) (42 USC 6901–6992k)
Rivers and Harbors Act (RHA) (33 USC 407–426p)
Toxic Resources Control Act (15 USC 2601–2629)
Water Resources Development Acts (WRDAs) (Biennial)

Source: U.S. Maritime Administration. Revised (December 21, 1998) presentation: A Report to Congress on the Status of Public Ports of the United States, 1996–1997.

ECOLOGICAL IMPACTS

Endangered Species

In 1973, Congress passed the Endangered Species Act (ESA), which required all federal agencies to undertake programs for the conservation of endangered and threatened species and prohibited those agencies from authorizing, funding, or carrying out any action that would jeopardize a listed species or destroy or modify its critical habitat. To determine the impacts of a proposed action on an endangered species, an agency must assess the baseline environment with regard to the species, and then consider the direct, indirect, interrelated, and interdependent effects of the proposed action. The agency reaches a final decision after it considers the total cumulative effects and determines whether the proposed action will have an unavoidably detrimental effect on the endangered species or its habitat. "Under section 7(a)(2) of the ESA, the federal agency must insure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat" (U.S. Fish and Wildlife Service, 1996).

Table 3.2 shows the federally listed endangered and threatened species for Texas coastal counties (Appendix A lists the endangered and threatened species for each county). The listing of a species might mean that it resides in that county; however, a listing might also mean that a species migrates, winters, or breeds through the area, or that the county occurs within that species' "range." The range of a species is determined by a number of factors, including past occurrences, habitat requirements, literature references, and migratory pathways (Dorinda Scott, August 19, 1999). In the case of an endangered bird, it might be that a county lies within its migratory pattern and the bird stops there only to rest for a short period before continuing its trek. The destruction of this bird's resting habitat could cause much of the population to perish.

Ports can be particularly disruptive—both directly and indirectly—to the habitats of Texas' endangered species. Direct impacts could occur when the construction of a port affects shorelines that are the nesting places of endangered sea turtles or affects the salt water marshes and coastal habitats that are attractive to migratory and coastal birds. Additionally, ships create the potential for risk to species like the endangered sea turtles, since the turtles could be injured, maimed, or killed by a ship's propeller. Indirectly, ports may affect endangered species' habitats by creating the demand for new development around the port that converts additional coastal habitat to man-made uses. Such development poses other hazards to endangered animals and plants.

Table 3.2. Federally Listed Endangered and Threatened Species—Texas Coastal Counties

Species	**Status**
Amphibians	
Houston Toad (*Bufo houstonensis*)	LE
Birds	
Peregrine Falcon (*Falco peregrinus*)	E/SA
American Peregrine Falcon (*Falco peregrinus anatum*)	LE
Arctic Peregrine Falcon (*Falco peregrinus tundrius*)	E/SA
Attwater's Greater Prairie-Chicken (*Tympanuchus cupido attwateri*)	LE
Bald Eagle (*Haliaeetus leucocephalus*)	LT-PDL
Brown Pelican (*Pelecanus occidentalis*)	LE
Eskimo Curlew (*Numenius borealis*)	LE
Interior Least Tern (*Sterna antillarum athalassos*)	LE
Northern Aplomado Falcon (*Falco femoralis septentrionalis*)	LE
Piping Plover (*Charadrius melodus*)	LT
Whooping Crane (*Grus americana*)	LE
Mammals	
Black Bear (*Ursus americanus*)	T/SA
Jaguar (*Panthera onca*)—extirpated	LE
Jaguarundi (*Felis yaguarondi*)	LE
Louisiana Black Bear (Ursus americanus luteolus)	LT
Ocelot (*Felis pardalis*)	LE
Red Wolf (*Canis rufus*)—extirpated	LE
West Indian Manatee (*Trichechus manatus*)	LE
Reptiles	
Atlantic Hawksbill Sea Turtle (*Eretmochelys imbricata*)	LE
Green Sea Turtle (*Chelonia mydas*)	LT
Kemp's Ridley Sea Turtle (*Lepidochelys kempii*)	LE
Leatherback Sea Turtle (*Dermochelys coriacea*)	LE
Loggerhead Sea Turtle (*Caretta caretta*)	LT
Vascular Plants	
Black-laced cactus (*Echinocereus reichenbachii var. albertii*)	LE
Slender rushpea (*Hoffmannseggia tenella*)	LE
South Texas ambrosia (*Ambrosia cheiranthifolia*)	LE
Star Cactus (*Astrophytum asterias*)	LE
Texas prairie dawn (*Hymenoxys texana*)	LE
Texas ayenia (*Ayenia limitaris*)	LE

Note: Federally Listed Endangered and Threatened Species for the following counties: Aransas County; Brazoria County; Calhoun County; Cameron County; Chambers County; Galveston County; Harris County; Jefferson County; Kenedy County; Kleberg County; Matagorda County; Nueces County; Orange County; San Patricio County; and Willacy County.

Codes: LE, LT—Federally Listed Endangered/Threatened
E/T/SA—Federally Endangered/Threatened by Similarity of Appearance
LT-PDL—Federally Listed Threatened/Federally Proposed Delisted

Source: Texas Parks and Wildlife Department, 1998–1999.

Unique Terrestrial and Aquatic Habitats

The Texas coast contains many sensitive terrestrial and aquatic habitats that could be affected by the construction and operation of a port. For example, oak and brush mottes are important terrestrial habitats along the coast, providing as they do resting places for migratory songbirds. Without a sufficient number of these mottes, many birds would perish after their long migration across the Gulf of Mexico. The migrating birds must have these resting points to rest, feed, and drink as soon as they reach land, since they are too exhausted to fly even short distances further. In fact, many of the birds never make it to shore. There are also colonial nesting sites located on the barrier, spoil, and natural islands of bays and estuaries. Some of these nesting places support federally endangered species like the Brown Pelican. Additionally, barrier islands, bays, estuaries, and coastal zone prairies and woods provide migratory routes for many protected raptors like the Peregrine Falcon. Many other birds, including federally listed species, depend on beaches and bayside mudflats for wintering. Sea turtles also nest along some Texas beaches (the precise locations known only to the federal government).

Important aquatic habitats along the coast are the many bays and estuaries that form as the fresh water flows into the Gulf of Mexico. These bays and estuaries serve as a "nursery" for finfish, crab, shrimp, and oyster beds. The seagrass beds within the bays and estuaries are especially critical, since they provide shelter for the young and a habitat for the other invertebrate fauna that occupy these areas (Dorinda Scott, August 19, 1999).

Air, Water, and Land Pollution

Regional Ambient Air Quality. The Clean Air Act of 1990 (CAA) allowed the Environmental Protection Agency (EPA) to establish standards for ambient air quality and for these standards to be implemented, maintained, and enforced by the individual states and the EPA. Title 1 of the CAA established national ambient air quality standards (NAAQS) for specific pollutants, particularly carbon monoxide (CO^2), lead, nitrogen dioxide (NOX), particulate matter, ozone, volatile organic compounds (VOCs), and sulfur dioxide. Regions that do not meet the NAAQS criteria are classified as nonattainment areas and must be brought into compliance under a State Implementation Plan (SIP). The SIP identifies the source of pollution and what methods will be used to bring the area into compliance (EPA Sector Notebook Project—Water Transportation, 42–43). Six of the fifteen counties along the Texas coast are considered nonattainment areas for local air quality. These six counties, located along the upper Gulf Coast, include Brazoria County, Chambers County, Galveston County, Harris County, Jefferson County, and Orange County. If stricter air quality standards take effect in the year 2000, many other areas could be considered nonattainment areas as well. The EPA subjects those areas receiving a nonattainment designation to a number of federal guidelines and restrictions, which add to the costs of transportation and which may limit the funds available for transportation improvements. Near-nonattainment regions are threatened with these restrictions and must guard against falling into the nonattainment category.

The concentration of a large number of diesel-burning vehicles that are found in a port means that these areas contribute to the build-up of ozone, CO^2, NOX, and other gases in a regional air-shed. In nonattainment areas, the servicing of containerships would likely require an examination of how these ships, along with the equipment and vehicles that handle their cargo, affect local air quality. Normal port operations can also fall under the scrutiny of the EPA for their effects on local air quality. For example, the use of paints and solvents for ship refurbishing and repairs can release ozone into the air, as can ship refueling. The EPA has also established requirements for the servicing and disposal of air conditioning and refrigeration equipment that contain ozone-depleting refrigerants. Thus, ports located within a region with nonattainment status may find the SIP placing many restrictions and limitations on their activities (EPA Sector Notebook Project—Water Transportation, 50–51).

Water Pollution. The water polluting activities of seagoing vessels are primarily regulated by a framework created under the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matters (MARPOL) in 1972. The regulations promulgated by this convention consist of five annexes, each of which addresses a different type of marine pollution. Generally, the convention regulates the dumping of oil, toxic substances, and sewage. The convention also sets minimum distances at sea for the disposal of garbage and forbids the dumping of plastics.

Water pollution within U.S. territorial waters and at ports is controlled under a different set of environmental regulations. The Ocean Dumping Act of 1972, which is the first two titles of the Marine Protection, Research and Sanctuaries Act (MPRSA), prohibits all ocean dumping without a permit in any waters under U.S. jurisdiction by U.S. vessels or ships sailing from U.S. ports. The Act created a comprehensive ban on the dumping of most highly toxic substances and provides for the permitted dumping of other substances, provided there is no danger to the public or the environment. The EPA has primary responsibility for regulating ocean dumping — with the exception of dredging spoils, which are regulated by the U.S. Army Corps of Engineers.

The Federal Water Pollution Control Act (FWPCA) regulates wastewater and storm water discharged into surface waters from marine facilities. A National Pollutant Discharge Elimination System (NPDES) permit must be obtained if wastewater is to be discharged into the navigable waters of the U.S. As of 1997, there were "no specific effluent limitation guidelines established for marine operations, although other wastewater discharge restrictions may apply." Marine facilities that "have vehicle maintenance shops or equipment cleaning operations are considered to have a storm water discharge associated with industrial activity." However, the permit is required only for those portions of the facility that carry on those operations. The Clean Water Act (CWA) also requires facilities to develop Spill Prevention, Control, and Countermeasure (SPCC) plans for petroleum products, such as oil or any other substance that creates a sheen on water, provided they are stored in large quantities at the port. Under the SPCC program, marine facilities must report spills into navigable waters and develop spill contingency plans (U.S. Environmental Protection Agency, 44–47).

Hazardous Substances. The Resource Conservation and Recovery Act of 1976 (RCRA) amended sections of the Solid Waste Disposal Act governing solid hazardous waste management. It was drafted with the intent of creating a "cradle to grave" system of regulations for managing hazardous waste, from generation to disposal. Some of the important aspects of RCRA are the following:

- Requires that facilities determine whether a substance is hazardous, solid waste, or whether it is exempted from regulation.
- Created record keeping guidelines for the generators of hazardous waste.
- Prohibits the disposal of hazardous substances on land without prior treatment.
- Created regulations for the storage, transportation, burning, processing, and refining of used oil.
- Contains the standards for units used to store, treat, or dispose hazardous waste and testing requirements.
- Regulates underground storage tanks for petroleum and hazardous materials.
- Provided design and performance standards for boilers and industrial furnaces that burn fuel oil containing hazardous waste. It also requires emissions monitoring and limits the type of waste that can be burned (U.S. Environmental Protection Agency, 32–34).

Ports, in their normal operations, regularly create waste items that are regulated by the RCRA. Many of these hazardous substances, such as paints or sludges, are generated at vessel refurbishing or maintenance facilities. Other materials produced by normal ship operations, such as scraps of certain metals and burned-out fluorescent light bulbs, would also fall under the purview of RCRA. Petroleum products and wastes are exempted, unless they have hazardous waste characteristics. The RCRA also applies to the underground storage tanks used for the refueling of ships. Given this wide range of regulated activities, many water transportation facilities qualify as hazardous waste generators under RCRA (U.S. Environmental Protection Agency, 48).

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, commonly known as Superfund, authorizes the EPA to respond to the release or threatened release of hazardous substances that could endanger public health or the environment. CERCLA allows the EPA to force those responsible for environmental contamination to clean up or reimburse the EPA for costs incurred for cleanups. The EPA directs these cleanups according to the procedures of the National Oil and Hazardous Substances Pollution Contingency Plan. This plan contains the procedures for permanent cleanups, which are known as *remedial actions.* In general, the EPA undertakes remedial actions only at sites placed on the National Priorities List (i.e., a Superfund site) (U.S. Environmental Protection Agency, 32–35).

Other water pollution laws affect port activities. The Oil Pollution Act of 1990 "establishes strict, joint and several liability against facilities that discharge oil or which pose a substantial threat of discharging oil to navigable waterways." Marine facilities must also follow a battery of public notification requirements if hazardous substances are released or spilled into the environment. Many of these requirements have been outlined under the Emergency Planning and Community Right-to-Know Act (U.S. Environmental Protection Agency, 48–49).

DREDGING IMPACTS

Sediment Disposal and Contamination

Most ports in the U.S., and certainly those in Texas, do not have sufficient natural depth to service containerships. As a result, the dredging of ports and their channels is a necessary requirement for ship mobility and safety. Additionally, because ships handle large quantities of military equipment, it is in the nation's security interest to maintain and improve its ports and channels. However, the removal of this sediment and its subsequent relocation can have serious consequences to the natural environment. The goal is to continue to maintain and improve U.S. ports and channels while minimizing the environmental impacts.

The U.S. Army Corps of Engineers has regulatory authority over all dredging projects in the U.S. and directs the disposal of dredging spoil.

> When dredged sediments are disposed of in ocean, inland, or near-coastal waters, a Corps permit is required. For the dumping of dredged material in the ocean, including the territorial sea, the applicable statutory provision is Section 103 of the MPRSA. If the discharge is in waters of the United States, excluding the territorial sea, then Section 404 of the Clean Water Act (CWA) is the applicable provision (U.S. Maritime Administration, 58).

The Corps reviews all proposed projects and ensures that they comply with the Rivers and Harbors Act (RHA), the CWA, and the MPRSA. The CWA directs the EPA to produce the criteria that the Corps uses to evaluate the impacts of proposed projects (U.S. Maritime Administration, 58).

What might appear as a relatively straightforward regulatory process rarely functions in that manner. Most dredging projects go through extensive periods of regulatory review because of inadequate preparation by government entities, insufficient exchanges of information between the stakeholders, or uncertainties about the scientific data and the risk factors that might arise from the proposed projects. Dredging projects may also experience delays because funding is not allocated at the expected time (U.S. Maritime Administration, 58–59).

Previous instances of sediment testing have revealed that only about 5 percent of dredged sediments were contaminated; but the percentage has been growing as a result of new testing requirements (U.S. Maritime Administration, 58). Contaminated sediments become a problem when they pass a threshold that affects public health or plants and fauna. Some of the substances contaminating marine sediments include trace metals, hydrophobic organics (like dioxins), PCBs, and polyaromatic hydrocarbons. Long-term exposures of these substances are more hazardous short-term exposures (Committee on Contaminated Marine Sediments, 22–25).

If dredged sediments are contaminated with mercury or cadmium compounds, organohalogens, or petroleum hydrocarbons, then they cannot be dumped in ocean waters. The sediments can, however, be dumped into inland waters, provided the requirements of Section 404 of the CWA are met. These sediments can also be disposed of on land, with the restriction that if hazardous waste characteristics are involved, the sediments must go to approved RCRA facilities. The upshot of this abbreviated discussion is that contaminated sediments unleash an extensive regime of environmental regulations that significantly increase the time span and costs of dredging.

Salt Water Encroachment

The dredging of ship channels can have the effect of changing the salinity of bays and estuaries, since the increased floor depth and channel width provides additional area for water to circulate. Thus, as dredged channels cut into fresh water estuaries, they become more brackish as the salt water circulates from the ocean into the fresh water environment. The dredging of channels alone, however, is not necessarily the sole agent of fresh water salinity changes, since a reduction in the flow of fresh water into the sea can also have the effect of increasing salinity (most commonly caused by droughts). Changes in bay and estuary salinity may prevent certain species from breeding or make the water body inhospitable owing to the species' sensitivity to the change. The overall effect depends on the change in water saline levels and the sensitivity of the organisms inhabiting that water body. Whether dredging has negatively affected vegetative areas of wetlands has yet to be determined. It has been argued that salt water intrusion "does not appear to be a major indirect factor driving coastwide land loss this century (although it may be significant in certain local areas)" (Turner, 8).

Coastal Zone Management

The Coastal Zone Management Act of 1972 (CZMA) created a program whereby states and territories voluntarily develop plans to protect and manage coastal resources. In 1997, there were twenty-nine federally approved programs. The goal of each program is to protect and manage important coastal resources, such as wetlands, estuaries, beaches, dunes, barrier islands, coral reefs, and fish and wildlife and their habitat. These resources may be managed through state laws, regulations, and/or permits and through local plans and zoning ordinances (U.S. Environmental Protection Agency, 52).

The State of Texas presented its most recent CZMA plan in August 1996. The goal of Texas' program was to develop a comprehensive plan for managing its coastal resources, which have been experiencing increased pressure as a result of population and economic growth. This growth has degraded dune complexes, coastal wetlands, and water quality in bays and estuaries. With regard to the human environment, increased development has made populations living along the Texas coast more susceptible to flooding, storm surges, and wind damage. Texas ports have required deeper dredging to maintain their viability, and the disposal of contaminated materials has become a major issue. The current plan is based on the Coastal Coordination Act of 1991,[4] which called for the development of a comprehensive coastal program based on existing regulations (Texas Coastal Management Program, I-1).

Port engineers and planners need to consider the goals of the state CZMA plan when proposing port improvements and construction, particularly with respect to the environmental concerns already mentioned: the disposal of dredging spoil and the effects on coastal wetlands, bays, and estuaries. The Coastal Coordination Act is important because it establishes "fundamental legal requirements that selected 'networked' state agencies and local governments must comply with, and enforcement of the uniform policies when the networked agencies take an action or develop rules that may adversely affect a coastal natural resource area" (Texas Coastal Management Program, I-1).

HUMAN ENVIRONMENT

Land Use

The direct land use impact of port improvements and construction is to convert a parcel of land from its current use to that of a port. Ports also stimulate land use conversions to surrounding parcels as well. As port activities grow, firms using or serving the port often seek land nearby to build their facilities. Existing developed land may be converted from residential and retail properties into commercial and industrial land uses. As port activity grows, the surrounding area often becomes increasingly less desirable for residential uses, which hastens this transformation.

Social Impacts

This conversion of land surrounding a port to commercial and industrial uses means that existing residents begin to experience the effects of growing commercial and industrial activity. Quiet local roads may become busy thoroughfares for trucks and other traffic

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[4] 33 Texas Natural Resource Code Ann. §201 et. seq.

serving the port, while firms and other facilities begin locating nearby. The effects of this increased activity, among many others, are often higher traffic volumes, higher ambient noise levels, and a higher risk of exposure to pollutants.

Schools, churches, cemeteries, nursing homes, hospitals, libraries, and many other public facilities are particularly sensitive to the externalities of a port's operation. A port's externalities are also disruptive to nearby residents, especially when these impacts have the effect of degrading or displacing functioning neighborhoods and communities. Disproportionate impacts to minority neighborhoods can also create problems. Presidential Executive Order 12898 requires that federal agencies collect and analyze information concerning a project's effects on minorities or low-income groups when required by the National Environmental Policy Act of 1969. If such investigations find that minority or low-income groups experience disproportionately adverse effects, then avoidance or mitigation measures must be taken.

It is important for local governments and port authorities to plan development both within and around the port to minimize the amount of disruption experienced by nearby residents. Without adequate planning, federal and state laws may require expensive mitigation for nearby residents and public facilities in response to a port's impacts.

Noise Impacts

The noise levels of ports and harbors are not specifically regulated by any federal agency, but some ports choose to follow the noise guidelines of the Federal Highway Administration (FHWA), in addition to requirements outlined by the EPA, Occupational Safety and Health Administration (OSHA), and local ordinances. In the case of the FHWA, the agency's regulations require reasonable mitigation for activities impacting public and residential structures wherein noise levels exceed an absolute criterion of 66 dB or a relative criterion of 10 dB higher than the baseline ambient noise level. In the case of ports, there are a number of activities that can contribute to the ambient noise level: the removal and replacement of large ship hatches; the placement of containers upon truck chassis so they can be driven to the RTGs; and the picking up and stacking of containers by the RTGs within the container yard. Most, if not all, of the equipment for loading and unloading ships and moving the containers uses heavy machinery powered by diesel engines. Sending a container outside a port often requires placing the container upon a diesel truck that carries it to its final destination. When these trucks leave the port, they must use public roadways to take the container to its destination. Since most of the containers leaving Texas ports do so by truck, the arterials serving ports often have high volumes of truck traffic, and that in turn raises noise levels along the roadways. Other sources of port noise include trains (and their loading equipment) and port-related services like shipbuilding, ship repair, and warehousing.

Historical and Archeological Sites

Federal law protects archaeological sites considered to have significant value under Section 106 of the National Historic Protection Act of 1966 (NHPA). The NHPA also created the National Register of Historic Places and requires that the Advisory Council for Historic Preservation be allowed to review and comment on projects that affect cultural resources that could be eligible for the National Register of Historic Places. The NHPA is invoked whenever a project makes use of federal funds or requires a permit from a federal agency.

The State of Texas also protects cultural resources on land owned or controlled by the state under the Texas Antiquities Code (Texas Natural Resources Code, Title 9, Chapter 191). The Texas Antiquities Code identifies these cultural resources as State Archeological Landmarks and accords to them special protection. If a proposed project is expected to impact a prehistoric or historic site, it may be necessary for some manner of protection and/or mitigation. Typically, the impacts to prehistoric and historic sites are determined through archeological surveys; if significant cultural resources are found, archeological testing may be required. Political subdivisions of the state must comply with these laws.

In addition to terrestrial structures or sites, ports must also consider structures and sites located underwater, especially sunken ships. A ship that sank before 1900 is considered (along with its content) a State Archeological Landmark and is eligible for listing on the National Register of Historic Sites.

> Sunken or abandoned pre-twentieth century ships and wrecks of the sea, and any part of the contents of them, and all treasures imbedded in the earth, located in, on, or under the surface of land belonging to the State of Texas, including its tidelands, submerged land, and the beds of its rivers and the sea within jurisdiction of the State of Texas, are declared to be state archeological landmarks and eligible for designation (Antiquities Code of Texas—Sec. 191.091).

The disruption or taking of prehistoric or historic sites along the Texas coast can require extensive agency coordination at both state and federal levels and expensive mitigation. Avoidance is often the best remedy when there are impacts to important archeological and historical sites and structures.

CHAPTER FOUR
LOCATIONAL ATTRACTION AND LANDSIDE ACCESS

INTRODUCTION

Aspects of locational attraction are quite abstract when compared to other parameters of port development. Environmental criteria, for example, are easy to understand because they are based on public laws or on easily identifiable experiences. Choosing the criteria of locational attraction, on the other hand, requires making gross assumptions about regional economic behavior. The first part of this chapter briefly reviews recent research as to why economic activity tends to agglomerate in central cities. Thus, in the context of serving containerships, it is critical that a port serves areas of concentrated economic activity, since the introduction of a port alone is no longer a sufficient factor to alter this almost intrinsic pattern of regional development.[5] The second part of this chapter will provide an overview of some the issues surrounding landside access, concentrating on the problems that arise when containers leave the port en route to their final destination.

As transportation costs began to decline significantly, regional economists began discounting the usefulness of classical location theories in explaining the location of firms. Classical location theories, in general, made the assumption that manufacturing occurred in single-location companies that used one input to produce a single product. This perception of the present manufacturing process is quite flawed, since many manufacturing facilities are part of large multinational corporations that own a number of plants, with each of these plants producing a variety of goods using a number of inputs.

There have also been fundamental changes in the way corporations do business, as flexible manufacturing and interfirm arrangements have become the norm. These changes have meant that firms have fewer locational restrictions than during previous periods. Thus, while economic agglomeration in a regional sense is the norm, individual firms also have and exercise the option of dispersing their facilities to several or many locations (Malecki, 112).

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[5] In other words, building a port in an area without substantial economic activity is unlikely to draw a significant number of firms. This assertion does not apply when existing ports are in inefficient locations.

Agglomeration

The agglomeration of economic activity allows firms to have access to specialized services and materials, including a large labor pool (Malecki, 124). Firms that are dependent on the exchange of information are particularly drawn to large cities, since communications occur more easily and frequently. Additionally, larger cities seem to "sustain a certain level of creativity not easily found or generated in other settings," and this is important to information-based firms. Surprisingly, noninformation-based industries also appear to show similar tendencies (Malecki, 150–156).

> Even data-entry jobs, which are found in many locations around the world as well as in rural regions of advanced economies, show a tendency to agglomerate in major urban centers and in some off-shore locations with pools of high-skill, low-cost labor (Malecki, 150).

Large-scale mass production appears to have the least need to agglomerate, since innovation is not aggressively pursued at most standardized manufacturing facilities. Provided the transportation system is adequate, locating a standardized manufacturing process outside of large cities allows firms to take advantage of lower labor costs.

Empirical models have also reinforced the idea that economic activity tends to agglomerate. In a two-region model of interregional trade, Krugman (1991) found a concentration of industries when the regions were homogenous and where there was no comparative advantage (the model included transportation costs). Krugman (1993) also achieved similar results with a three-region model in two-dimensional space connected by a transportation network. Fujita et al. (1995) produced a model with a multiple-sector economy that allowed them to analyze the process of city formation and development, where the city locations in the model were endogenously determined. The model results showed the development of a hierarchy of cities, although it was located in a one-dimensional space (no distance assumed between city nodes). Finally, Mun (1997) created a model, which included many industrial sectors into an urban system, wherein the cities were exogenously determined (chosen by the researcher), but in which the structure of these industries was endogenously determined (chosen by the model). Mun studied city size, distribution, and the industrial structure produced by various transportation networks. He found that economic activities agglomerated in cities that lowered transportation costs, although improving the transportation links tended to redistribute populations (Mun, 205–207).

Agglomeration in the Context of Ports

In practical terms, what does all this mean to ports? First, because there is a strong tendency for economic activity to agglomerate, ports located near large cities are therefore in a stronger competitive position than are ports in less developed areas. Even though transportation costs are no longer the only deciding factor, firms still tend to locate near one another to gain access to skilled labor and specialized inputs. Second, time is an important factor, especially for those firms involved in flexible manufacturing (e.g., just-in-time practices). The location of a port far from economic activity creates longer shipping periods that firms may find unacceptable. Third, ports have market areas, and the market areas for less densely developed areas are relatively small. Port market areas along the Texas coast have established themselves into a hierarchy of sorts, in which the Port of Houston is the highest-order port. Without very significant changes in the distribution of population and employment, this hierarchical pattern is relatively permanent, and it will be difficult for smaller ports to compete.

Ports should not, however, limit their view of market areas to just Texas or even to the Southeastern or Southwestern U.S. Ports should also realize that Mexico offers the potential for expansion. Significant amounts of nonmaquiladora manufacturing occur along Mexico's northern border region, particularly in the city of Monterrey. The Port of Houston currently engages in substantial container trade with Mexican customers, and it seems reasonable that ports further south could also tap into this market. On the other hand, international borders do distort the size and pattern of market areas. Physical areas that would be easily covered within a country are made smaller or are eliminated as market areas by international borders. This is because crossing international boundaries increases the transport costs and time requirements of shipments (Hoover, 216–222). Smaller ports could also be in a competitive position to provide container service to customers in their immediate area who are currently receiving container service from an existing containerport. If smaller ports could provide regularly scheduled liner service, local customers could probably realize significant time savings.

LANDSIDE ACCESS

The landside access discussion of this section will concentrate on the movement of containers from the port to their final destination. While it is important that ships be efficient in their travel and operation, as should ports in the loading and unloading of containers, any efficiencies gained in these areas could be lost if the landside transportation network is poor. Given the large amount of literature currently available on this subject, the following narrative will simply be a broad overview of important issues.[6] It should be pointed out that the final document of Project 0-1833 will examine landside access issues in substantially more detail and will contain a modal split forecasting model.

Roadway Issues

The continuing expansion of the U.S. economy, along with the increase in single-passenger vehicular travel, has meant that vehicular demand is quickly outstripping expansions of the roadway network. The growing demand for roadways, with no subsequent or adequate increase in supply available to meet this demand, has resulted in increased congestion. In fact, one could safely state that roadway congestion has become a pandemic problem for almost every major metropolitan area in the U.S. Highway congestion is relevant to shipping because highways are the dominant method by which containers are moved from ships to market and from producers to ships. The trucks moving these containers must compete for available roadway space—a space that is constantly diminishing. The effects of growing congestion on cargo transport include longer travel times and higher shipping costs. Unfortunately, there does not appear to be any solution to roadway congestion in the foreseeable future. While there continues to be expansion of the

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[6] An excellent, but slightly dated, review of landside access issues was published by the Transportation Research Board (1993) and is entitled *Landside Access to U.S. Ports*. The study sent eighty-five questionnaires to AAPA member ports and received fifty-four responses. These fifty-four ports accounted for 87 percent of all exports and imports handled by U.S. ports in 1990.

roadway network, there is not enough funding to build all needed roadways. Even if all the desired roadways could be built, most planners believe that this construction would not provide a long-term solution to the problem. The new roadways would simply fill up, as have the existing roads, and congestion would return. Despite efforts to relieve commuter congestion with public transportation projects or through the promotion of alternative travel modes, the overall effect of these efforts has been minimal at best, and such efforts are rarely popular except with a small segment of the population.

The Transportation Research Board's (TRB) 1993 study identified other roadway issues in addition to congestion. Among the issues identified were occasional problems with the turning radii of intersections around the port and other roadway design problems such as insufficient weight limits for bridges and low overpass clearances (TRB, 53–56).

Rail Issues

The transport of containers by rail, rather than by truck, provides opportunities for lower shipping costs and less roadway congestion. Obviously, there is less flexibility and speed with rail transport; it is most suitable for containers traveling 500 or more miles from the port. For shorter trips that are not cost-effective by rail or for time-sensitive goods, containers typically travel by truck (TRB, 44). Despite the opportunities it offers for cost savings and efficiency, rail also has its share of problems. The 1993 TRB survey found that two-thirds of the surveyed ports must share part of their rail line right-of-ways with public streets. Obviously, at-grade rail crossings add to roadway congestion and decrease mobility, as they interrupt the flow of traffic. Limits are often placed on train length to minimize the effects of roadway congestion; in addition, limiting train length ensures the mobility of emergency vehicles. However, these limits can prevent trains from minimizing their operating costs. Another problem is infrastructure impediments to double-stacking containers. In many instances, the use of double-stacked container trains is not an option because overpass bridges and tunnels do not have adequate clearance; the expense of upgrading these facilities would be cost-prohibitive (TRB, 56–58).

There have been other problems with railways, owing to the proprietary nature of rail infrastructure and limitations on its usage by competing companies. Unlike roadways that all private firms can use without discrimination, railroad tracks are privately owned, meaning rail carriers can often prevent their competitors from gaining access. Additionally, railways are private businesses and are occasionally subject to the complications that occur when they are bought or sold. The organizational chaos that followed the relatively recent merger of Southern Pacific with Union Pacific (UP) railroads had a devastating effect on Texas' rail efficiency. In the summer of 1998, the average train speed across the entire UP rail system was 14 miles per hour (mph), compared to 18 mph before the problems of the merger. While most observers seem to agree the UP rail crisis has ended, service has not returned to pre-merger levels (*Star Tribune,* 9D). There are also lingering questions both about the lack of competition among rail companies and about how future mergers will affect rail efficiency.

Potential Solutions to Landside Access Problems

The 1993 TRB study identified four possible solutions to the problems surrounding landside access. One solution is the construction of dedicated truck and rail freight corridors, like the Alameda Corridor in California. However, the construction costs of the Alameda Corridor are significant, with its final cost expected to be many times the original estimate. It is not uncommon to see project costs, in many cases poorly estimated during the planning stage to begin with, escalate significantly as a result of unexpected right-of-way acquisition and environmental mitigation. A second option is to bring rail into the port or even along the dock, a strategy that would decrease the number of times a container must be handled. While this appears to be a relatively straightforward idea, many rail companies are reluctant to modify their existing operations to fit the needs of a port, since the companies are already operating at substantial volumes and profits. A third option would be to sort containers at an inland terminal away from the actual port. Containers are shipped to the inland terminal from the port by rail and then separated. Containers distributed locally would be placed upon trucks, while those with more distant destinations would be forwarded by rail. A benefit of this option is that the terminal can locate in an area with lower land rents and away from the congestion. The two disadvantages of this option are: (1) it requires handling the container multiple times, and (2) the trains between the port and inland terminals themselves may create congestion. Finally, there is the option of shipping containers along intercoastal channels to inland ports instead of by truck and rail. The primary advantage of this option is a reduction in congestion and pollution. However, a 1993 law requiring that domestic goods being shipped within U.S. territorial waters be transported on U.S.-built ships precluded the cost-effectiveness of this option. Additionally, because of the removal of subsidies from the U.S. shipping industry, few U.S.-built ships are available for this purpose (TRB, 61–64).

CHAPTER FIVE

PORT FINANCE

The large sums of money required for port improvements are a serious constraint for many ports wishing to upgrade to a mega-containership or smaller containership status. Port upgrades often require dredging channels, constructing harbor facilities, and purchasing cranes and yard equipment. While the federal government provides the majority of funds for many dredging projects, ports or their local sponsoring entity are still required to make partial contributions. Along with the growing expense of dredging and infrastructure, the costs of environmental compliance are also increasing. An additional financial strain was created by the Tax Reform Act of 1986, which inhibits the ability of public ports to issue tax-exempt bonds (U.S. Maritime Administration, 4).

Ports receive their incomes from a variety of sources that might include, but are not limited to, usage tariffs, taxes, transfer payments from sponsoring government entities, bonds, and income earned from nonport-related activities and investments. The intense competition that exists between U.S. ports ensures that their tariffs will remain relatively low; consequently, it is difficult to employ usage charges alone to finance large-scale projects. Taxes are limited to the taxpayer's willingness to finance port operations, while transfer payments are subject to budgetary constraints and political environments. In the State of Texas, outside funding of port improvements is even more restricted since all transportation funds collected through vehicle fuel taxes are strictly earmarked for highway construction and maintenance and cannot be used for other purposes.

Despite these formidable problems, there is a surprising dearth of literature that addresses port finance.[7] Perhaps the best and most recent source of information on this topic comes from a 1994 study published by the U.S. Maritime Administration and written in

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[7] For a survey of creative port financing techniques across the U.S., see LBJ School of Public Affairs Report, *State Programs for Financing Port Development*. Austin: The LBJ School of Public Affairs, The University of Texas at Austin, 1997.

conjunction with the American Association of Port Authorities (AAPA).[8] This study was based on the findings of three surveys administered by the AAPA of U.S. ports along the Atlantic, Gulf, and Pacific coasts, as well as of ports along the Great Lakes and the Mississippi River. While the AAPA reviewed a number of issues relevant to port finance in the U.S., three appear to be the most appropriate for this discussion: self-sufficiency, profitability, and financial philosophy. Because this 1994 AAPA study was the only document identified as both relevant and timely to the topic of port finance, this narrative will draw almost exclusively from its findings and conclusions.

SELF-SUFFICIENCY

As of 1992, the AAPA found there was "no trend towards self-sufficiency nor increased profitability" among U.S. ports. In fact, Gulf of Mexico ports as a whole were among the least likely to show profitability. While the AAPA survey found that 56 percent of the responding ports claimed to be 100 percent self-sufficient, these claims were viewed with skepticism. Many ports included incomes they received from nonport-related activities, such as revenues derived from tunnel and bridge fees. Other ports did not consider the funding of projects from outside entities as their own debts, which they would be required to pay if they were fully self-sufficient. Table 5.1 provides two sets of definitions for port self-sufficiency, as identified by the AAPA.

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[8] U.S. Maritime Administration—Office of Port and Intermodal Development. *Public Port Financing in the United States*. Washington, D.C., July 1994.

Table 5.1. AAPA Definitions of Port Self-Sufficiency

Scenario One—Analysis Using Comprehensive Annual Financial Statements or Audits
Narrow self-sufficiency—The port's current revenue covers administrative and operating expenses, including maintenance and minor improvements of existing facilities. However, revenue is not high enough for the amortization of initial capital investments or major improvement and expansion work.
Relative self-sufficiency—The port is able to finance from operating income a portion of major port improvement projects, but relies on subsidies or grants to cover remaining costs.
Full self-sufficiency—The port relies exclusively on its own funds and earning capacity for all major improvements and maintenance costs.
Scenario Two—Analysis Using Condensed Statement of Revenue and Experience
No self-sufficiency—Negative operating income (operating loss) and negative net income (net loss) before taxes and contributions.
Narrow self-sufficiency—Negative net income (net loss) before taxes (received) and contribution is less than the amount of bond interest expense.
Relative self-sufficiency—Positive net income before taxes (received) and contributions, but still receives taxes and/or contributions.
Full self-sufficiency—Positive net income and receives no taxes and/or contributions.

Source: U.S. Maritime Administration, 29–30.

Notes: Operating income loss is defined (by AAPA) as operations revenue less operating expense, including depreciation expense.

PROFITABILITY

The number of Gulf ports reporting profitability has declined from ten in 1988 to three in 1992, while those reporting nonprofitability rose from eight to fourteen during the same time period. Some of the AAPA's explanations for declining profits were excess capacity, competition, and a continued reliance on transfer payments. Ports were considered profitable in the AAPA study if they showed a net profit before taxes and contributions. The AAPA considered ports to be unprofitable if they had a net loss before taxes and contributions (U.S. Maritime Administration, 39).

FINANCIAL PHILOSOPHY

Ports typically operate under three financial philosophies or some combination of these philosophies: the financial approach; the economic approach; and/or the business development approach. Under the financial approach, ports set their tariffs to cover operating costs, retire debt, and produce funds for future investment in facilities and equipment. The economic approach means that ports set their tariffs to break-even only.

The business development approach implies that ports view their primary function as promoting regional development. After analyzing the pricing strategies of ports in the survey, the AAPA found that the majority of ports operate under the financial approach or in combination with the other two approaches. The study found that only 11 percent of the ports state that they “exclusively try to maximize earnings” as their sole operating philosophy. Fifty-three percent of the responding ports said at least part of their operating philosophy was to increase regional economic activity, while fourteen of the forty-seven ports that responded said they did not try to maximize their profits. Among the Gulf of Mexico ports, more than half reported that they pursue the financial approach when pricing their vessel charges (U.S. Maritime Administration, 49–51).

The importance of a port’s financial philosophy is quite obvious. Ports that do not attempt to maximize their profits or that view their primary function as increasing economic activity are less likely to produce the funds necessary for major port improvements without additional assistance.

This chapter ends the report’s background narrative on the major issues surrounding containerport improvements and operations. The following two chapters will discuss the development of the port identification and evaluation processes.

CHAPTER SIX
LOAD CENTER SELECTION PROCESS

INTRODUCTION

This chapter describes a process designed to select a mega-containership load center among Texas ports in the Gulf of Mexico. In the design of this selection process, five major issues arose. The first of these issues was whether all ports would be considered "competitive" as a mega-containership load center when there are only a few Texas ports presently handling containers. In other words, should the number of ports receiving full consideration be reduced to those reasonably believed to be competitive? Second, which general issues or "parameters" should be included in the selection process and how should they relate to one another? These issues range from paying for port improvements to the port's effects on the environment. Third, what should be the specific criteria included within each of the matrix's parameters? For example, a more complete consideration of environmental impacts means examining a port's effects on water quality, endangered species, and neighborhoods, among other things. Fourth, how should the criteria within these parameters be scored and assessed? Finally, how should the individual criteria and the matrix parameters be weighted among each other, since their perceived importance, relative to another, often differs? Figure 6.1 illustrates the overall process of constructing the load center selection matrix.

The identification of a particular port for mega-containership service is ultimately the responsibility of ship operators who must determine whether such operations are, in fact, feasible and profitable. If ship operators do determine that serving mega-containerships could be feasible and profitable at a certain port, then the implementation of these plans would probably require infrastructure improvements financed, at least in part, by other parties. Specifically, these parties would be the U.S. Army Corp of Engineers, port operators, TxDOT, and local governments. When planning for improvements that would affect state-owned landside infrastructure, TxDOT has a legitimate role in the planning process and together, with officials from the different modes of transportation, should determine whether the existing roadway infrastructure could meet the expected demand. Under these circumstances, the identification process proposed in this chapter would be carried out by a team of individuals representing TxDOT, local transportation planners, port operators, ship operators, and local public officials.

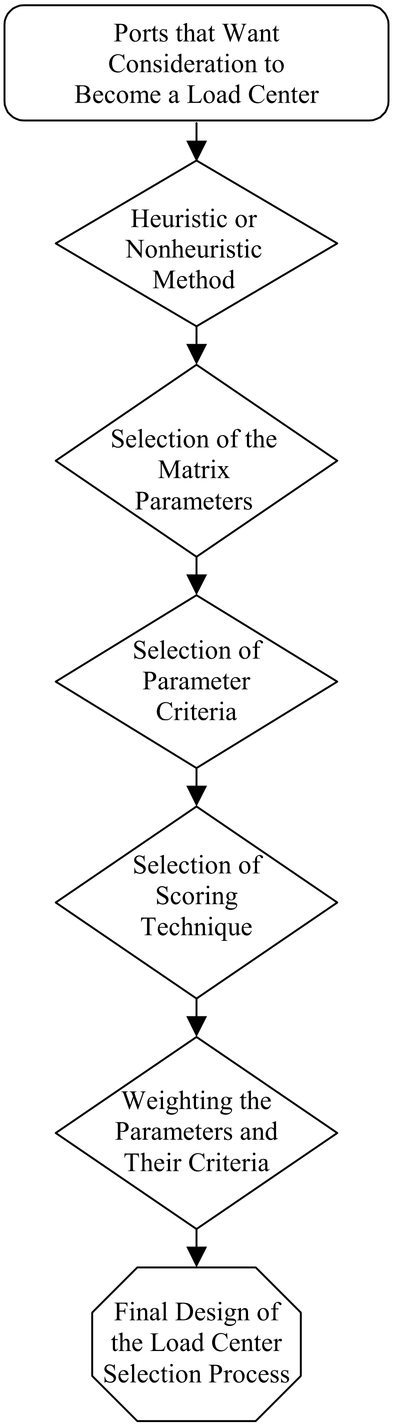

Figure 6.1. Construction of the Load Center Selection Process

A HEURISTIC VERSUS NONHEURISTIC METHOD

A heuristic method is one that "contributes to the reduction in the average search for a solution" (Ballou, 331).[9] Employing a heuristic method in the mega-containership port selection process might consist of a two-stage technique. The first of these two stages would eliminate noncompetitive ports before examining the competitive sites in a selection matrix. Two possible heuristic methods for this first stage are a "fatal flaw" analysis or a preliminary scoring matrix.

With the fatal flaw analysis, a port is assessed through a series of "yes" or "no" questions. These questions are arranged in a format that simulates a flowchart, in which an unsatisfactory answer to any of the questions eliminates a port from further consideration. Figure 6.2 provides an example of how this flowchart might appear. It is expected that most of the ports would "fail" the fatal flaw analysis and receive no further consideration, while ports that "passed" would be studied in greater detail in the selection matrix.

A second heuristic method is a preliminary scoring matrix wherein a port would be assessed and scored based on a series of criteria (see Table 6.1). For example, a criterion in the preliminary matrix might be "Is the port channel at least 40 feet deep?" If the answer is "yes," the desirable answer, a port receives one point. If the port's channel is less than 40 feet deep, it receives a score of zero. It may also be desirable to weight the questions in the matrix, so that more important issues like channel depth have a greater impact on the final results.[10] Additionally, TxDOT could weight the matrix to emphasize those port issues for which the department has resources for assistance, such as port connectivity. Criteria scores are then totaled for each port. Collectively, it is expected that the ports would form two groups: (1) a few ports with relatively high scores (or attractiveness for becoming a mega-containership port) and (2) the remaining majority of ports with relatively low scores (unattractive). Those ports receiving the highest scores are examined further using the detailed selection matrix, while ports receiving the lowest scores are eliminated from further consideration. The initial criteria for either the fatal flaw analysis or the preliminary matrix

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[9] Found in Newell, A. et al., "The Process of Creative Thinking," RAND Corporation Paper, p. 1370 (August 1958).

[10] A more detailed discussion of weighting is found later in this chapter.

would need to be determined by a technical advisory committee, while TxDOT would review, edit, and approve the final version.

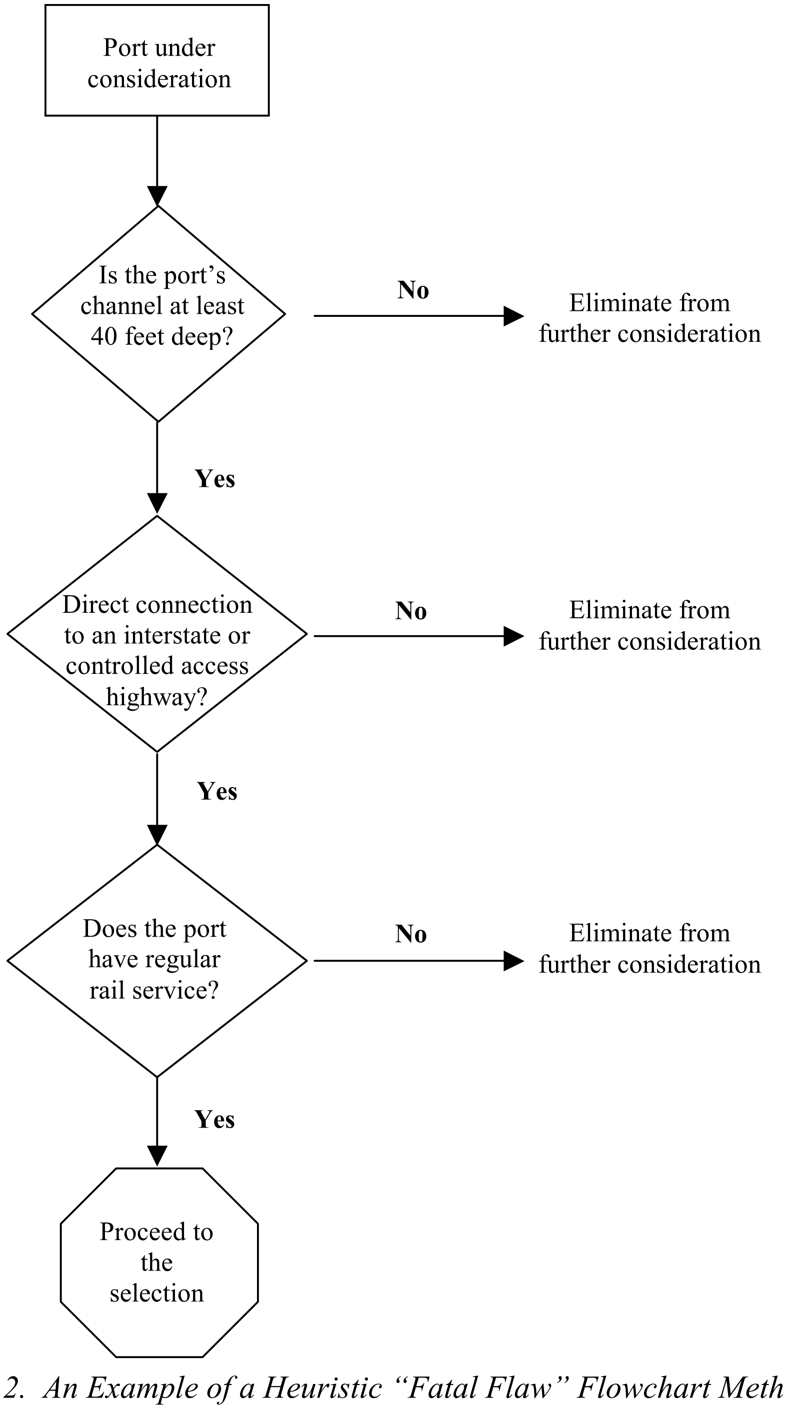

Figure 6.2. An Example of a Heuristic "Fatal Flaw" Flowchart Method

Table 6.1. An Example of a Heuristic Preliminary Matrix

Score	Response		Preliminary Criteria
	No	Yes	Existing channel depth—40 feet or more or a permit for 40 feet or more (yes = 1 point, no = 0 points)?
	No	Yes	Existing channel width—800 feet or more (yes = 1 point, no = 0 points)?
	No	Yes	Existing roadway network—nearby controlled-access freeway connecting to an interstate (yes = 1 point, no = 0 points)?
	No	Yes	Multi-directional connections—nearby connections to north-south and east-west interstate roadways (yes = 1 point, no = 0 points)?
	No	Yes	Existing railyard (yes = 1 point, no = 0 points)?
	No	Yes	More than one rail company providing service (yes = 1 point, no = 0 points)?
	No	Yes	Existing container facilities (yes = 1 point, no = 0 points)?
	No	Yes	Congestion—rail (yes = 0 points, no = 1 point)?
	No	Yes	Congestion—road (yes = 0 points, no = 1 point)?
	No	Yes	Land available for expansion (yes = 1 point, no = 0 points)?
			Total Score

Both the fatal flaw and the scoring methods are effective tools in eliminating noncompetitive ports early in the selection process. The scoring method may be more acceptable to smaller ports, since no port is immediately ruled out for failing to meet a single criterion. However, the fatal flaw method would be more efficient and would not allow a port with a very serious defect to remain in the selection process.

An alternative to the heuristic method would be to evaluate all ports in the more detailed selection matrix. The disadvantage of the nonheuristic approach is that additional time and effort are required to gather information on ports that are not likely to be competitive candidates. However, using the nonheuristic method might avoid the main criticism of the heuristic technique — that a port was eliminated for a single or a few reasons, even though it has many other attributes that would make it attractive as a mega-containership load center.

Ultimately, however, a fatal flaw analysis would have to be carried out for the ports chosen for further study using the heuristic preliminary matrix or nonheuristic method. Without the consideration of fatal flaws at some point in the process, a noncompetitive port could be selected as the best alternative.

MATRIX PARAMETERS AND SENSITIVITY ANALYSIS

Selection matrices typically consist of several "parameters" that encompass the major issues surrounding a project. With the inclusion of a variety of parameters in the selection process, a narrowing of alternatives can occur. It is believed that this narrowing approach leads to the selection of a problem's optimal solution. Conceptually, this idea is similar to finding an optimal minimum or maximum point in linear programming. In considering the optimal location for a mega-containership port, it is important to include such parameters as infrastructure requirements, financing issues, environmental impacts, and locational demand and landside access. Below is a list of parameters included in this selection matrix.

- *Infrastructure Requirements* — The minimal level of infrastructure necessary for a mega-containership port compared to the existing infrastructure at each port examined in the research project. The port needing the least amount of infrastructure improvements would be considered the optimal site.
- *Environmental Impacts* — Infrastructure improvements and port operations create impacts on both the natural and human environment. This parameter would consider the current state of the environment and the potential consequences of action. The location creating the fewest environmental impacts would be considered the best location.
- *Locational Demand and Landside Access* — Consideration of a port's proximity to market centers and its intermodal facilities and service. The port serving the largest market with best landside access would be the best choice.
- *Port Finance* — Measures of a port's ability to finance the necessary improvements to become a mega-containership port. Ports able to finance improvements with the least amount of external funds would be the most attractive.

After choosing the selection matrix parameters, it is necessary to determine how they relate to each other. Thus, multiple parameters cannot be scored separately without first creating some type of common measurement. Without this common unit of assessment, producing a consistent method for evaluating each port would be difficult. Having a common unit of measurement for each parameter's overall score permits the option of a sensitivity analysis, which allows each parameter score to assume a range of importance in relation to the other parameters. The purpose of varying a parameter's importance, or its weight, is to determine whether the matrix produces consistent findings. Thus, a "valid" selection matrix would generally choose the same alternative most of the time, even as the parameters' weights change. If, as the parameters' weights change, there are great fluctuations in the optimal choice, the selection matrix is considered a questionable decision-making tool. The purpose of a sensitivity analysis is to acknowledge the matrix's inherent subjectivity and to consider decisions from differing points of view. Unfortunately, performing a sensitivity analysis does not remove these problems, though it does attempt to account for them.

THE CRITERIA

Once the parameters of the selection matrix are chosen, it is then necessary to decide which criteria should be included within those parameters. The criteria included in the selection matrix were based on an extensive literature review and on a site visit to the Port of Houston. Tables 6.2 through 6.5 show the selection criteria for the infrastructure demands, environment, locational demand and landside access, and port finance parameters.

Table 6.2. Criteria for the Existing Infrastructure Parameter

I. Marine Access

- *Channel*
  - Depth
  - Width
  - Length—distance from sea
  - Overhead clearance
  - Submerged obstacles (i.e., extensive pipeline systems, tunnels, etc.)
  - Corps permit for further dredging
  - Bedrock depth
- *Turning Basins*
  - Depth
  - Turning area diameter
  - Length
  - Width
- *Berths*
  - Length of the longest berth
- *Congestion at Sea*
  - Average queuing time for a ship entering the dock

II. Port Operations

- *Container Facilities*
  - Existing container facilities
  - Container movement efficiency
  - Acreage available for future development
- *Cranes*
  - Number of Post-Panamax cranes
  - Number of Post-Panamax cranes capable of serving a mega-containership
- *Dockside Congestion*
  - Dockside container-moving equipment
  - At least 50 acres per ship berth?
  - Sufficient space for the container staging area
  - Dockside rail access
- *Congestion within the port*
  - Average time for empty trucks to enter, be loaded, and leave the port
  - Average time for empty trains to enter, be loaded, and leave the port

Table 6.3. Criteria for the Environmental Impacts Parameter

I.	**Ecological Impacts** Endangered species habitat or observations within or surrounding the port area Presence of unique aquatic or terrestrial fauna and vegetation within or surrounding the port area Areal disruption of previously undisrupted habitat
II.	**Air and Water** EPA air-quality certification (e.g., nonattainment) Number of on-going waterway clean-up projects required and overseen by the Texas Natural Resources Conservation Commission or the EPA Number of hazardous waste spills in the last five years Presence of hazardous waste disposal facilities Number of port or tenant hazardous waste disposal violations within the last five years Number of on-going hazardous waste clean-up projects overseen by the Texas Natural Resources Conservation Commission or EPA Number of EPA Superfund sites within the port
III.	**Dredging Impacts and Coastal Zone Management** Approved location for the disposal of dredging spoil Estimated area of sediment contamination within the port channel Substantial salt water encroachment into fresh water habitats? Are port expansions consistent with the statewide Coastal Zone Management Plan?
IV.	**Human Environment** Estimated area of residential development within one-half mile of the port's perimeter Number of schools, hospitals, nursing homes, etc. surrounding the port Do current noise impacts from the port require mitigation? Number of archeological or historical sites (terrestrial or submerged) located within the port or its channel

Table 6.4. Criteria for the Port Financing Parameter

I.	**Estimated Costs** Estimated costs of all port infrastructure improvements to serve a mega-containership Estimated costs of all landside improvements outside of the port
II.	**Public-Private Sector Port** Public or private port Value of current private sector improvements to the port
III.	**Bonds Issuance and Taxing Authority** Does the port have the legal authority to issue bonds? Most recent Moody's (or Standards and Poor's) bond rating of borrowing entity Current bond debt-to-revenue ratio Special taxing district or taxing authority?
IV.	**General Financial Characteristics** Is the port self-sufficient (using definitions under Scenario 1 of Figure 7.1)? Is the port profitable (port shows a net profit before taxes and contributions)? Assets-to-liabilities ratio Debt-to-revenue ratio
V.	**Intergovernmental Grants** Total local government funding received over the past 5 years Total nonlocal government funding received over the past 5 years

Table 6.5. Criteria for the Locational Attraction and Landside Access Parameter

I. Market Area Estimated population within 50 miles of the port Estimated manufacturing and warehousing employment within 50 miles of the port Value of goods transported to customers located outside of Texas
II. Proximity to Texas' Central Cities Estimated travel time to downtown Houston Estimated travel time to downtown Dallas Estimated travel time to downtown San Antonio
III. Proximity to Mexico Estimated travel time to Monterrey, Mexico Estimated travel time to Laredo-Nuevo Laredo Estimated travel time to El Paso-Ciudad Juarez
IV. Land Access *Rail* Presence of rail service within the port Number of companies servicing the port Presence of rail switching yard *Roads* Number of road lanes connecting the port to interstates and controlled access highways *Congestion outside of the port* Travel time necessary to leave the metropolitan area surrounding the port by road Direct access to interstate highways or controlled access highways connecting to interstate highways North-south and east-west access to interstate highways Travel time necessary to leave the metropolitan area surrounding the port by rail At-grade crossings Adequate clearance for double-stack containers

SCORING METHOD

After selection of the matrix parameters and criteria, it is necessary to produce a scoring method. Scores can be based on a comparison of discrete counts, measurements, and yes-no answers or subjective estimates of impact. An example of discrete count would be the number of cranes at a port or the depth of its channel. Examples of a binary answer include whether a port's expansion fits into a state's coastal zone management plan or whether a port has dockside rail access. Obviously, simply reducing complex issues like coastal zone management or intermodal planning to yes or no answers limits the depth of analysis, but the purpose of a matrix is to somehow methodically and uniformly consider many different types of information.

The comparison method of discrete counts, measurements, and binary answers would rank alternatives against each other. For example, if the channel depths of three ports were 35, 40, and 45 feet, respectively, the port with the 35-foot channel would receive the lowest rank, while the port with the 45-foot channel would receive the highest rank. The shallowest channel would receive the lowest score since more dredging would be necessary, which not only is expensive but also requires extensive regulatory compliance. The same process would occur for all the criteria in each of the parameters.

A ranking would perhaps provide five categories of assessment: "poor," "below average," "average," "above average," and "good" (see Table 6.6). The ranking technique allows for some flexibility, since the alternatives can be compared to one another or to some other standard. Many of the rankings, such as infrastructure characteristics, could be derived from studying the characteristics of other ports. In other words, if 60 percent of the Gulf's ports had a channel depth of 39 to 41 feet, that range could become the standard for the "average" ranking. However, it should be understood that some rankings are somewhat subjective in nature and are determined by the norms and values of the individual making the assessment. The use of a Delphi approach when defining the rankings could limit this bias, provided the panel is well chosen. Delphi panels consist of a group of experts that follow an iterative process of reaching a group consensus on a particular matter. During instances in which ship operators are attempting to select a port to service mega-containerships, the Delphi panel would likely consist of company employees (with special expertise) and hired consultants. When the issues involve landside infrastructure, the panel might include representatives of state and local transportation agencies, port operators, shipping agencies, and other relevant professionals.

The comparison method of assessing alternatives tends to give the impression of a more absolute or precise alternative selection and is commonly used in engineering projects. Ranked scores are viewed as being “softer,” or less definitive, and are more often found in planning than in engineering studies.

Table 6.6. An Example of a Ranked Score Matrix

I. Marine Access	**Port A**	**Port B**	**Port C**
Channel			
Depth	4	3	3
Width	4	3	1
Corps permit for further dredging	1	5	1
Bedrock depth	3	4	3
Turning Basins			
Depth	4	3	3
Turning area diameter	3	3	4
Length	3	2	3
Width	2	2	3
Berths			
Length of longest berth	5	3	2
Congestion at Sea			
Average queuing time for a ship to enter the port	2	4	5

1 = poor **2 = below average** **3 = average** **4 = above average** **5 = good**

Channel Definitions

Depth: 30–34 feet = poor; 35–38 feet = below average; 39–41 feet = average; 42–45 feet = above average; more than 45 feet = good

Width: 200–324 feet = poor; 325–474 feet = below average; 475–524 feet = average; 525–650 feet = above average; more than 650 feet = good

Corps permit: "Yes" = good; "No" = poor

Bedrock depth: Less than 50 feet = poor; 50–64 feet = below average; 65–79 feet = average; 80–94 feet = above average; more than 95 feet = good

Turning Basin Definitions

Depth: 30–34 feet = poor; 35–38 feet = below average; 39–41 feet = average; 42–45 feet = above average; more than 45 feet = good

Turning Area Diameter: less than 1,000 feet = poor; 1,000–1,199 feet = below average; 1,200–1,299 feet = average; 1,300–1,500 feet =above average; more than 1,500 feet = good

Length: 1,000–1,999 feet = poor; 2,000–2,999 feet = below average; 3,000–3,999 feet = average; 4,000–4,999 feet = above average; 5,000 feet or more = good

Width: 1,000–1,499 feet = poor; 1,500–1,999 feet = below average; 2,000–2,499 feet = average; 2,500–2,999 feet = above average; more than 3,000 feet = good

Berth Definitions

Length: 2,000–2,999 feet = poor; 3,000–3,999 feet = below average; 4,000–4,999 feet = average; 5,000–5,999 feet = above average; more than 5,000 feet = good

Congestion at Sea Definitions

Average queuing time: 5 hours or more = poor; 3–5 hours = below average; 1–2 hours = average; less than 1 hour = above average; no wait = good

WEIGHTING

Not all the issues that are considered in a selection process are of equal importance. Depending on costs, the regulatory environment, and public opinions and values, some issues are considered to be more or less important than others. When issues of differing importance are combined into a single decision-making tool, "weighting" the issues prevents a large number of less important issues from driving a decision that would be seriously affected by a few major ones. The selection matrix weighting would be hierarchical: each parameter would receive a weight of the total score and each of the parameter's subcomponents and their criteria would be weighted. Table 6.7 provides an example of how the criteria of the selection matrix might be weighted. In this example, the subcomponent, called channel, was weighted at 26 percent of the total parameter score, while the criterion of channel depth was given the weight of 13 percent. The selection team would determine the weights assigned to each of the matrix's parameters, subcomponents, and criteria.

WEIGHTING THE MATRIX CRITERIA

There are at least four issues that should be considered when choosing a weighting technique: objectiveness, mathematical complexity, software requirements, and public access. The weighting methods discussed in this section have both pros and cons, which prevents any one of them from being an optimal solution. Thus, planners should seek a consensus among all members involved in the port planning process to determine the most appropriate tool. Table 6.8 summarizes some—though not all—of the issues surrounding each of the weighting methods presented here.

Table 6.7. An Example of a Matrix Segment with Comparison Rankings and Weighted Scores

	Weight	**Port A**	**Rank**	**Score**	**Port B**	**Rank**	**Score**	**Port C**	**Rank**	**Score**
I. Marine Access *	50%									
Channel **	26%									
Depth ***	13%	45	3	0.39	40	2	0.26	35	1	0.13
Width	5%	600	3	0.15	500	2	0.10	250	1	0.05
Corps permit for further dredging	5%	No	1	0.05	Yes	3	0.15	No	1	0.05
Bedrock depth	3%	75	2	0.06	80	3	0.09	70	1	0.03
Turning Basins	15%									
Depth	8%	45	3	0.24	40	2	0.16	35	1	0.08
Turning area diameter	5%	1,200	1	0.05	1,250	2	0.10	1,500	3	0.15
Length	1%	3,000	3	0.03	2,500	1	0.01	3,000	3	0.03
Width	1%	2,000	1	0.01	2,000	1	0.01	3,000	3	0.03
Berths	7%									
Length of longest berth	7%	6,000	3	0.21	4,000	2	0.14	3,500	1	0.07
Congestion at Sea	2%									
Average queuing time for a ship to enter the port	2%	3 hours	1	0.02	1 hour	2	0.04	0 hours	3	0.06
Subtotal Score				**1.21**			**1.06**			**0.68**

* Parameter subcomponent level

** Criteria grouping level

*** Criteria level

Table 6.8. A Comparison of Criteria Weighting Techniques

Issue	**Delphi Method**	**Q-Methodology**	**Analytical Hierarchy Process**
Objectiveness	Depends on subjective input. Few structural restrictions to avoid politicization.	Depends upon subjective input. Quantitative analysis may diminish politicization.	Depends on subjective input. Quantitative analysis may diminish politicization. Tests for inconsistencies.
Mathematical Complexity	Math not required.	Intermediate Statistics (Factor Analysis).	Basic matrix multiplication.
Software Requirements	None necessary.	Most easily performed with statistical software.	Spreadsheet software.
Public Access	Easy to explain to the general public, but potentially difficult to defend.	Easy to explain theoretically, but difficult to explain at the detailed operational level.	Difficult to explain.

Delphi Method

Instead of using quantitative techniques to weight parameter criteria, the Delphi method assembles a group of informed individuals for this process. The first step in the Delphi method is to select and gather this group of individuals who have knowledge of ports and of the requirements of mega-containerships. This panel of experts would probably consist of local government officials, planners, consultants, academicians, and private-sector representatives. Once gathered, the panel is given questionnaires or lists of parameters, parameter subcomponents, criteria, and criteria grouping to weight. In order to weight these items or to respond to the questionnaires, the panel members rely on their personal knowledge as well as on additional information and analyses provided to them by the port selection team. The results from this first iteration are compiled and distributed to the panel members. The panel analyzes and discusses the results of this first-iteration weighting, paying special attention to any outliers produced by the group. The panel then performs another iteration of weighting, in light of their analyses of the first, and produces the final weighting. It may be necessary, in some circumstances, to perform more than two iterations before the panel members agree that the results are acceptable.

Q-Methodology

While Q-methodology has some similarities to the Delphi method, it uses statistical techniques to determine when a consensus has been reached. The method has been described as a "technique for studying human subjectivity" and was developed to avoid the validity and interpretation problems of surveys, the "small and unrepresentative" issues surrounding focus groups, and the complexities of presenting multivariate analysis to the public. Since each person perceives the world differently, it is difficult to create a method that acknowledges these differences. Q-methodology concentrates on finding patterns across the subjective beliefs of panel members. The first step in the method is to identify a panel—as with the Delphi method—whose members are then asked to contribute statements about the importance of each parameter, parameter subcomponent, criteria, and criteria grouping. Members of the group are asked to rank-order their statements to reflect their personal viewpoints. The variation in the ordering of statements is subjected to statistical analysis, specifically factor analysis. The factor analysis reveals the dominant patterns of belief among the panel, which are then used to produce the criteria weightings (Steelman and Maguire, 362–364).[11]

Analytical Hierarchy Process

Analytical hierarchy process (AHP), a third possible technique to weight the parameter criteria, is based on matrix multiplication.[12] Using AHP, the panel would need to weight the criteria in three tiers by first determining the ranking of the parameters, then the parameter subcomponents, the criteria grouping, and finally the individual criteria. Using the environmental parameter as an example, the panel would create a list of objectives common to all four subcomponents: ecological impacts, air and water impacts, dredging impacts and

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[11] For a detailed discussion of the Q-methodology technique see Steelman, Toddi A., and Lynn A. Maguire. "Understanding Participant Perspectives: Q-Methodology in National Forest Management." *Journal of Policy Analysis and Management*. Vol 18., No. 3, 361–388 (1999).

[12] To avoid a complicated discussion of the matrix multiplication, this narrative will concentrate on the overall technique of AHP. Individuals interested in the mechanics of AHP can refer to Winston, Wayne, and S. Christian Albright. *Practical Management Science: Spreadsheet Modeling and Applications*. Albany, New York: Duxbury Press, 1997.

coastal zone management, and impacts on the human environment. These objectives would be ranked against one another and their rankings represented through integer values. The integer values would then be converted into a pairwise comparison matrix and used to produce a weighting for each objective. With these weightings, the panel can produce a numerical rank score for each parameter subcomponent that determines their relative importance to one another. These scores can then be used to create numeric weightings for each of the parameter's subcomponents. One important benefit of AHP is that it also contains a method for checking the internal consistency of the rankings, which adds confidence to the final results (Winston and Albright, 363–376).

ANALYSIS OF WEIGHTING TECHNIQUES

The competitiveness of ports and their sensitivity to assessment mean that any weighting technique for the selection matrix criteria is likely to undergo intense scrutiny. Since there is no purely objective means to weight the criteria, a technique must be chosen that has credibility among the evaluators and those being evaluated. Since all techniques require a panel, one option for invoking confidence is to choose panel members from outside of Texas and/or without direct relationships with Texas ports. Once the panel is chosen, and if there are few concerns about objectiveness, then the Delphi method is a practical option. In other situations, the evaluation team may want to further diminish perceptions of subjectivity and/or they may be comfortable with the quantitative techniques. In these cases, the evaluation team could choose either Q-methodology or AHP to reach these goals. One benefit of AHP over the Delphi method and Q-methodology is that it allows the panel members to check the internal consistency of their weightings, an advantage that is likely to inspire additional confidence in the final results.

The mathematical complexity of a technique is another important issue to consider when weighting criteria. While the Delphi method does not require the use of mathematics, both Q-methodology and AHP require more than a basic grasp of mathematical techniques. Although factor analysis, which is employed by Q-methodology, is a common statistical tool in the social sciences, it requires a reasonably strong background in statistics to properly interpret results and to identify potential threats to validity. Using Q-methodology would also require an analyst with a proficient knowledge of statistical software. AHP requires knowledge of matrix multiplication, which is conceptually less complicated than factor analysis. While it is a mechanically complex procedure, it is nonetheless one that can be programmed into spreadsheet software.

Additionally, evaluators must consider the ease with which they can explain these processes in a public environment. While a complicated weighting process like AHP has desirable characteristics, including greater objectivity and checks for consistency, it is difficult to explain to a nontechnical audience. Individuals lacking the technical background often feel uncomfortable with such methods. As a result, audiences may simply accept the conclusions because they come from "experts," or they may reject them as a manipulated "black box." Neither of these two possible outcomes is desirable when one seeks meaningful public input. The Delphi method, on the other hand, is much easier to explain to the general public, but may be harder to defend if the results differ substantially from public attitudes. Q-methodology enjoys the advantage of quantitative analysis and is easy to explain at a superficial level. However, if pressed by the public for a detailed description, it too may quickly be viewed as a "black box" analysis.

CONCLUSIONS

The selection team chooses the components of the matrix from the alternatives provided in this chapter. Specifically, the team members should choose a heuristic or nonheuristic approach. If the heuristic approach is chosen, the team members then determine whether to use the fatal flaw or preliminary selection matrix methods. Other decisions to be made by the selection team include how the matrix will be scored, how the scores will be weighted, and whether any sensitivity analyses will be performed. The next chapter discusses the conversion of the selection process into an evaluation process.

CHAPTER SEVEN

A CONTAINERPORT EVALUATION PROCESS

The evaluation process of this report does not compare the advantages and disadvantages of one port to those of another port. The purpose of this process is to provide port operators and landside planners with an organized and methodical approach for considering facility improvements. Unlike the selection matrix, this evaluation does not produce a score that recommends the feasibility or desirability of port improvements. The final assessment is left to the individual ports. However, it is hoped that the evaluation provides an impetus for thoughtful debate and decision-making, while minimizing the pursuit of unreasonable goals. This analysis is meant to identify the constraints to port expansion and, if these constraints are not overwhelming, to produce a starting point for addressing these problems.

THE EVALUATION PROCESS

The evaluation process consists of six steps, as shown in Figure 7.1. An evaluation team composed of the port operator, representatives from TxDOT, and local transportation planners should collectively carry out these steps. If the port is located within a Metropolitan Planning Organization (MPO), the MPO planners should also have a role. The evaluation team may also wish to include local public officials and representatives from the shipping industry.

In the first step, port operators identify and document the containership size their port can presently serve, and then produce an inventory of their port's current infrastructure. The documentation requirement assures the accuracy of the port operator's assessment. Table 7.1 is meant to provide only a guideline of the characteristics to be identified in this inventory; ports should not limit themselves to these items alone. Documentation would also need to accompany this inventory to ensure its accuracy.

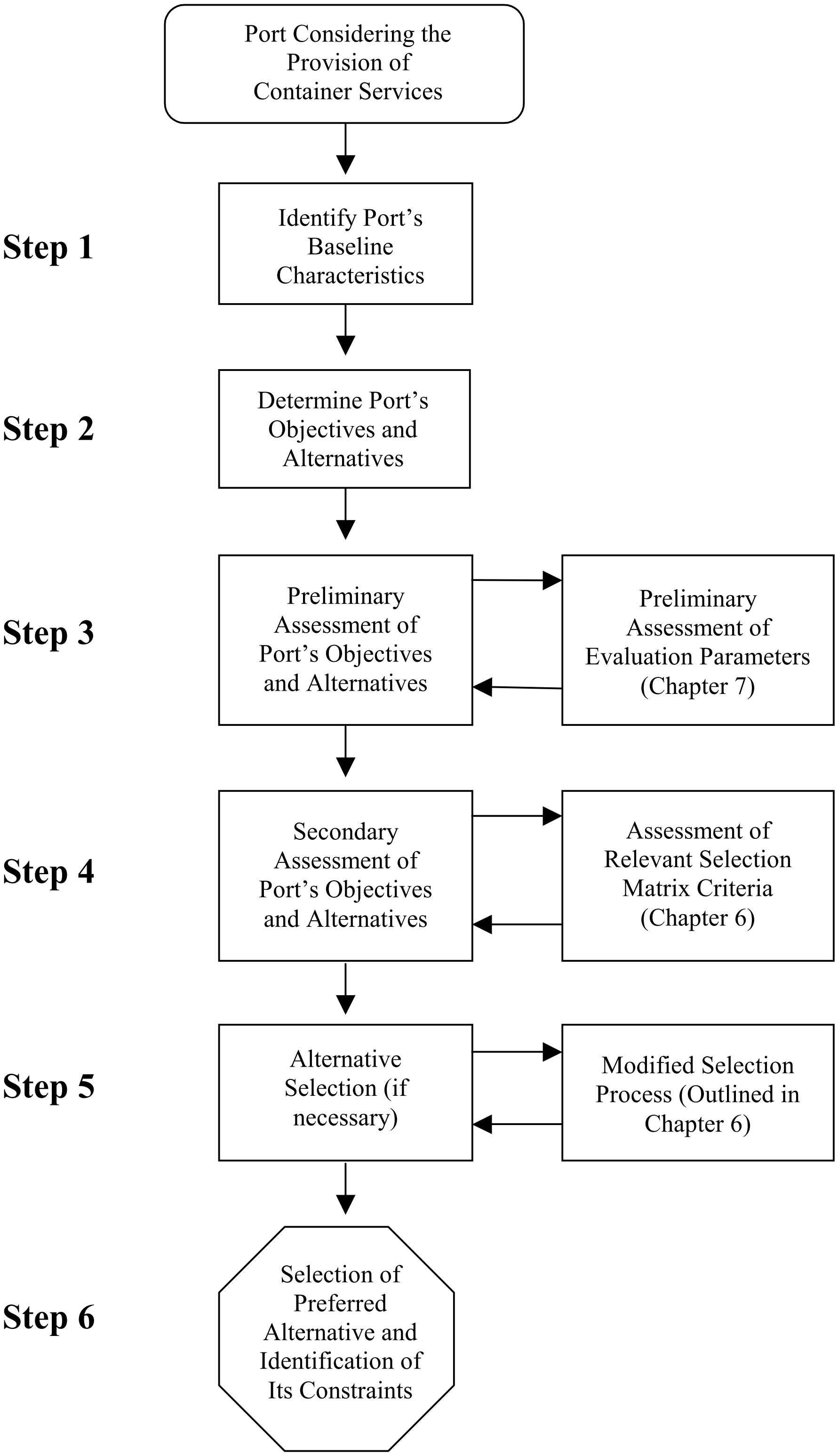

Figure 7.1. The Port Evaluation Process

Table 7.1. An Example of a Hypothetical Port's Inventory

Inventory Item	**Port's Characteristics**
Largest containership served	2,000 TEU
Scheduled container service	Not at present
Yearly throughput of TEUs	Less than 10,000
Channel depth	32 feet
Channel width	180 feet
Turning basin diameter	No turning basin
Number of berths	Two
Length of berths	2,000 feet total (1,000 feet each)
Container cranes	None
Other cranes	60-ton Gantry crane
Yard equipment	One 14-ton front-end handler
Available acreage	200 acres
Rail access at the port	Yes, not dockside
Connections to major highways	Yes, north-south interstate

Source: Adapted from VZM TransSystems, 1997.

As a second step, the port operators propose the size of containership they wish to service, along with a detailed inventory of the necessary infrastructure. The proposal may be either for containerships of a single size or for containerships of differing sizes, and it should address the items listed in the port inventory, in addition to any other items deemed relevant. Table 7.2 shows the requirements to serve a Class V containership (6,000+ TEUs). Producing both an inventory and a proposal table simplifies the comparison and identification of the necessary improvements.

Table 7.2. Requirements to Serve a Class V Containership

Inventory Item	**Port's Characteristics**
Largest containership served	6,000+ TEUs
Scheduled container service	Yes
Yearly throughput of TEUs	450,000–900,000 TEUs per year*
Channel depth	50 feet
Channel width	800–1,000 feet
Turning basin diameter	1,430–1,650 feet
Number of berths	Two or more
Length of berths	1,250 feet
Container cranes	6–10 Super Post-Panamax Cranes (150-foot reach)
Other cranes	Useful, but not necessary
Yard equipment	RTGs, yard tractors, etc.
Acreage	150 acres
Rail access at the port	Yes—preferably dockside
Connections to major highways	Yes—preferably controlled-access freeways

* Excluding transshipments
Source: VZM TransSystems, 1997

The third step is a preliminary analysis of the proposed improvements; answers are provided to questions listed under each of the parameter headings found in the next section of this chapter. Thoughtful and accurate answers to these questions will provide a general opinion of whether a port should consider the improvements. The answers should include as much relevant and detailed information as possible, since a generalized reply would run counter to the intended purpose of the analysis. The information required to respond appropriately to these questions goes well beyond that provided in this report, and evaluators should seek to gather as much project-specific data as possible. If the answers to these questions do not affirm the need to improve the port or if doubt cannot be resolved, then perhaps the port should consider delaying any immediate improvement plans.

As a fourth step, if the responses to the preliminary analysis lead the evaluation team to believe that port improvements appear desirable, the evaluators should return to Chapter 2 and address the detailed parameter criteria. However, not all of these criteria may be relevant to individual ports. In such cases, the ports should document their reasons for excluding the irrelevant criteria and address the remainder.

In the fifth step, the evaluation team selects between the port improvement alternatives, if there are more than one. The selection process outlined in Chapter 2 is a useful and methodical approach (with appropriate alterations). The evaluation team would need to construct the selection process from the options provided.

The final step of this exercise is an identification of constraints to port improvements. These constraints should have become obvious to the evaluation team during the third, fourth, and fifth steps. As the final product, the evaluation team should determine its preferred alternative and list that alternative's constraints so that the team can then plan its future course of action. This exercise should prepare the port to carry out further MIS and environmental studies in a more efficient and knowledgeable manner.

PRELIMINARY ASSESSMENT EVALUATION PARAMETERS

Infrastructure Demands

The infrastructure demands of port improvements depend on the existing infrastructure and the class of ship the port seeks to serve. Ports should consider the following questions.

1. Will upgrading the port to serve containerships or a larger containership require deepening and/or widening the channel? Is the port's turning basin of adequate depth and diameter (if one exists at all)?
2. Does the port have an adequate berth length?
3. Does the port currently service containerships? Upgrading or starting these services may require new container-handling equipment (i.e., cranes, rubber tire gantries, container tractors, etc.) and warehousing facilities. Are these acquisitions affordable?
4. Are there adequate road and rail connections to the port, along with the transportation infrastructure within the port, to serve containerships?

Probably the most important of these characteristics to port operators are those related to channel depth and width. Upgrading a port's service often means dredging its channel and turning basin to serve containerships—an expensive process that requires substantial environmental compliance. These costs are added to the acquisition of container-handling equipment whose expenditures are related to the size of ship served. Container-handling equipment is not inexpensive, and a single crane can cost millions of dollars. Finally, is the transportation infrastructure leading into the port adequate, and does the port have the necessary equipment to move containers in and out efficiently? If these conditions do not exist, it is not likely to be cost- and time-effective for nearby users to switch to the local port.

Environmental Issues

Environmental issues become relevant if there is new construction or a significant increase of activities. As a preliminary effort, port authorities should ask themselves the following questions.

1. Will it be necessary to dredge the port's channel?
2. Would port expansion cause any significant disruptions or destruction of natural habitats?
3. Is the port currently disruptive to its surrounding neighbors?
4. What is the port's current relationship with local environmental and neighborhood groups?

If a port channel requires additional dredging or the development of additional land, environmental regulations will most likely need to be considered. Also, if activities at the port will increase the levels of noise, pollution, and traffic, even without infrastructure improvements, these activities may be subject to regulatory requirements. Without acknowledgment of the impacts on the local population, a port will certainly be open to future problems. A contentious relationship with environmental and neighborhood groups may not prevent a project from being constructed, but it can certainly delay the process, with such delays translating into additional costs.

Locational Attraction and Landside Access

Whether a port could become competitive as a containerport depends in part on the surrounding market size and the ship size being considered for service. At present, the majority of containers in Texas enter through the Port of Houston, with additional containers entering through the ports of Galveston and Freeport, Texas. Thus, considering the current pattern, a port should answer several questions before deciding to enter the container business or before upgrading its facilities to serve a larger ship.

1. How large is the port's hinterland, and who are the port's current customers?
2. Who are potential container shippers? Which container shippers in the area are currently using other ports but could be better served by a local port?
3. Is it financially feasible for containership operators to serve the port?
4. Is the roadway and rail infrastructure sufficient, both within and beyond the port, for moving the desired number of containers?

Ports located in regions of the state with relatively low population densities do not have large hinterlands and, since other ports already serve denser areas, may not be able to expand their influence. Many of the smaller ports have industry-specific customers who typically ship break-bulk and/or liquid cargoes and do not serve a range of customers. With regard to Question 3, owing to the competitiveness of the shipping industry, shippers are extremely reluctant to enter into markets unless they are very confident that those markets will be profitable. Shipping companies are probably the best source of information when it comes to answering this question, since very sophisticated techniques for assessing the profitability of port calls have been developed. In addition to market size, ports should be concerned about landside access. Ports should determine whether they have the infrastructure or the ability to build the infrastructure needed to move containers from the port to the hinterland and vice versa.

Finance Issues

Regardless of a project's feasibility and likelihood of success, nothing can be done if the project cannot secure funding. The investments necessary for a port to become a containerport are substantial. Purchasing expensive container equipment, then hoping there is sufficient use of the equipment so that it pays for itself, is a risky venture. Below are several finance questions a port should consider.

1. What are the total estimated infrastructure and equipment costs of the improvements sought?
2. Can the port realistically afford the improvements that it is seeking? From what source will the funds be obtained? How much additional income does the port expect after the improvements?
3. What realistic financing options does the port have outside of usage tariffs?

The costs of port improvement may not be limited to cranes, dockside container-moving equipment, staging areas, and warehouses. There may also be costs associated with dredging, turning basin, and berth construction. Accordingly, ports must consider the totality of the costs involved. In order for a port to determine whether it can realistically afford the improvements it seeks, it should be self-sufficient and profitable. Other issues to consider are whether the port has taxing authority, if it can sell bonds, and if there are private sector users willing to pay for a portion of the improvements.

CHAPTER EIGHT
CONCLUSIONS

BACKGROUND

The purpose of this report is to assist TxDOT and port operators in the decision-making process of expanding port services. Rather than concentrating solely on selecting a load center for the Gulf of Mexico, the project was enlarged to include a containerport evaluation process suitable for any Texas port, irrespective of its size. In part, this decision was reached because of the low likelihood of mega-containerships using ports in the Gulf of Mexico in the near future. The selection of a North Atlantic load center outside the Gulf could bring about a hub-and-spoke system in which routes radiating from a load center could include calls on ports currently not receiving containerships. TxDOT has an interest in improving highway access and connectivity to all marine sites, so a general containerport evaluation process was developed in addition to the load center identification process.

INFRASTRUCTURE FOCUS

Trade flows through a port are the result of a series of economic decisions made by users and port operators. These decisions relate to both demand and supply characteristics, and the volumes of trade and the prices charged are a result of the interaction of the two. This simple economic fact should be remembered as TxDOT undertakes any port evaluation, whether it is strategic in nature (like Project 0-1833) or focused on engineering projects, such as gate productivity and access. The processes described in this report, both for the load center selection and for the containerport evaluation, focus on the infrastructure performance—that is, the supply side—and may cover marine channel issues, various elements of port operations, or landside access, and may even target one of these for scrutiny. TxDOT's responsibilities clearly indicate an interest in landside access issues, including the modes chosen for surface distribution. This report identified a hierarchy of evaluation activities and showed where the two deliverables of this particular research project fit into TxDOT's planning order. The hierarchy must also reflect elements of demand issues, since building facilities alone, whether based on transportation or port operation needs, may fail to attract maritime users. Growth in maritime demand and clear commitments to provide liner service to port facilities are necessary elements of the process, even though they are not part of the focus of Research Report 1833-2. These issues will be discussed in Research Report 1833-3.

LOAD CENTER SELECTION

The load center selection process was designed to select one port among all Texas Gulf ports to become a containership load center. The project team attempted to design this procedure to be fair and reasonable. The goals of fairness and reasonableness were pursued through extensive research into the issues surrounding containerport and load center characteristics. The research centered on infrastructure requirements, environmental constraints, locational attraction and landside access, and port finance. The findings were used to derive the parameters and criteria of the load center selection matrix, as well as to offer options for the scoring and weighting of these criteria. The selection process offered in this report is similar to other alternative selection methods used for transportation projects and provides the evaluators with an appropriate level of flexibility.

CONTAINERPORT EVALUATION

The containerport evaluation process provides all Texas ports the chance to evaluate their current facilities and to examine expansion opportunities in a methodical and organized manner. The evaluation process does not provide a negative or an affirmative answer to TxDOT, port operators, or transportation planners. These decision-makers are allowed to draw their own conclusions. However, the evaluation process encourages ports to identify the constraints that exist for sound port development plans, while providing more flexibility than the load center selection matrix. The final product of the port evaluation process is a clear plan for future development and a realistic understanding of the problems that must be addressed before these goals can be achieved.

RECOMMENDATIONS

In conclusion, this report makes two recommendations:

1. It is recommended that the selection and evaluation processes be assessed through a pilot test that would identify improvements for the final version of this report. This final version could then be used at the relevant Texas ports to capture the responses for TxDOT policy review.

2. It is recommended that TxDOT develop a database to store the responses to the evaluation and selection procedures. Storing these responses could be useful for several reasons. First, a database could ensure that the infrastructure information is included in the modified statewide transportation plan and that the issues that are currently constraining port efficiencies are identified and included in the statewide planning process. Second, this database could be easily updated, and the information could be made available to local transportation planners and hired consultants. The third function would provide TxDOT's multimodal staff with a repository of regularly updated port information that would improve their ability to handle port issues in a prompt and efficient manner and to evaluate the impact of related transportation investments on port efficiency.

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APPENDIX

ENDANGERED AND THREATENED SPECIES IN TEXAS COASTAL COUNTIES

Table A.1. Federally Listed Endangered and Threatened Species in Aransas County, Texas

Species	**Status**
Birds	
Peregrine Falcon (*Falco peregrinus*)	E/SA
American Peregrine Falcon (*Falco peregrinus anatum*)	LE
Arctic Peregrine Falcon (*Falco peregrinus tundrius*)	E/SA
Attwater's Greater Prairie-Chicken (*Tympanuchus cupido attwateri*)	LE
Brown Pelican (*Pelecanus occidentalis*)	LE
Interior Least Tern (*Sterna antillarum athalassos*)	LE
Eskimo Curlew (*Numenius borealis*)	LE
Piping Plover (*Charadrius melodus*)	LT
Whooping Crane (*Grus americana*)	LE
Mammals	
Red Wolf (*Canis rufus*)—extirpated	LE
Ocelot (*Felis pardalis*)	LE
Jaguarundi (*Felis yaguarondi*)	LE
Reptiles	
Atlantic Hawksbill Sea Turtle (*Eretmochelys imbricata*)	LE
Green Sea Turtle (*Chelonia mydas*)	LT
Kemp's Ridley Sea Turtle (*Lepidochelys kempii*)	LE
Leatherback Sea Turtle (*Dermochelys coriacea*)	LE
Loggerhead Sea Turtle (*Caretta caretta*)	LT

Table A.2. Federally Listed Endangered and Threatened Species in Brazoria County, Texas

Species	**Status**
Birds	
American Peregrine Falcon (*Falco peregrinus anatum*)	LE
Arctic Peregrine Falcon (*Falco peregrinus tundrius*)	E/SA
Attwater's Greater Prairie-Chicken (*Tympanuchus cupido attwateri*)	LE
Bald Eagle (*Haliaeetus leucocephalus*)	LT-PDL
Brown Pelican (*Pelecanus occidentalis*)	LE
Piping Plover (*Charadrius melodus*)	LT
Whooping Crane (*Grus americana*)	LE
Mammals	
Jaguarundi (*Felis yaguarondi*)	LE
Ocelot (*Felis pardalis*)	LE
West Indian Manatee (*Trichechus manatus*)	LE
Reptiles	
Atlantic Hawksbill Sea Turtle (*Eretmochelys imbricata*)	LE
Green Sea Turtle (*Chelonia mydas*)	LT
Kemp's Ridley Sea Turtle (*Lepidochelys kempii*)	LE
Leatherback Sea Turtle (*Dermochelys coriacea*)	LE
Loggerhead Sea Turtle (*Caretta caretta*)	LT

Table A.3. Federally Listed Endangered and Threatened Species in Calhoun County, Texas

Species	**Status**
Birds	
Piping Plover (*Charadrius melodus*)	LT
Peregrine Falcon (*Falco peregrinus*)	E/SA
American Peregrine Falcon (*Falco peregrinus anatum*)	LE
Arctic Peregrine Falcon (*Falco peregrinus tundrius*)	E/SA
Whooping Crane (*Grus americana*)	LE
Bald Eagle (*Haliaeetus leucocephalus*)	LT
Eskimo Curlew (*Numenius borealis*)	LE
Brown Pelican (*Pelecanus occidentalis*)	LE
Interior Least Tern (*Sterna antillarum athalassos*)	LE
Mammals	
Red Wolf (*Canis rufus*)	LE
Jaguarundi (*Felis yaguarondi*)	LE
Reptiles	
Loggerhead Sea Turtle (*Caretta caretta*)	LT
Green Sea Turtle (*Chelonia mydas*)	LT
Atlantic Hawksbill Sea Turtle (*Eretmochelys imbricata*)	LE
Kemp's Ridley Sea Turtle (*Lepidochelys kempii*)	LE

Table A.4. Federally Listed Endangered and Threatened Species in Cameron County, Texas

Species	**Status**
Birds	
American Peregrine Falcon (*Falco peregrinus anatum*)	LE
Arctic Peregrine Falcon (*Falco peregrinus tundrius*)	E/SA
Brown Pelican (*Pelecanus occidentalis*)	LE
Northern Aplomado Falcon (*Falco femoralis septentrionalis*)	LE
Piping Plover (*Charadrius melodus*)	LT
Mammals	
Jaguar (*Panthera onca*)—extirpated	LE
Jaguarundi (*Felis yaguarondi*)	LE
Ocelot (*Felis pardalis*)	LE
West Indian Manatee (*Trichechus manatus*)	LE
Reptiles	
Atlantic Hawksbill Sea Turtle (*Eretmochelys imbricata*)	LE
Green Sea Turtle (*Chelonia mydas*)	LT
Kemp's Ridley Sea Turtle (*Lepidochelys kempii*)	LE
Leatherback Sea Turtle (*Dermochelys coriacea*)	LE
Loggerhead Sea Turtle (*Caretta caretta*)	LT
Vascular Plants	
Black-laced cactus (*Echinocereus reichenbachii* var. *albertii*)	LE
South Texas ambrosia (*Ambrosia cheiranthifolia*)	LE
Star Cactus (*Astrophytum asterias*)	LE
Texas ayenia (*Ayenia limitaris*)	LE

Table A.5. Federally Listed Endangered and Threatened Species in Chambers County, Texas

Species	**Status**
Birds	
Arctic Peregrine Falcon (*Falco peregrinus tundrius*)	E/SA
Attwater's Greater Prairie-Chicken (*Tympanuchus cupido attwateri*)	LE
Brown Pelican (*Pelecanus occidentalis*)	LE
Interior Least Tern (*Sterna antillarum athalassos*)	LE
Bald Eagle (*Haliaeetus leucocephalus*)	LT-PDL
Piping Plover (*Charadrius melodus*)	LT
Mammals	
Red Wolf (*Canis rufus*)—extirpated	LE
Reptiles	
Atlantic Hawksbill Sea Turtle (*Eretmochelys imbricata*)	LE
Green Sea Turtle (*Chelonia mydas*)	LT
Kemp's Ridley Sea Turtle (*Lepidochelys kempii*)	LE
Leatherback Sea Turtle (*Dermochelys coriacea*)	LE
Loggerhead Sea Turtle (*Caretta caretta*)	LT
Amphibians	
Houston Toad (*Bufo houstonensis*)	LE

Table A.6. Federally Listed Endangered and Threatened Species in Galveston County, Texas

Species	**Status**
Birds	
American Peregrine Falcon (*Falco peregrinus anatum*)	LE
Arctic Peregrine Falcon (*Falco peregrinus tundrius*)	E/SA
Attwater's Greater Prairie-Chicken (*Tympanuchus cupido attwateri*)	LE
Bald Eagle (*Haliaeetus leucocephalus*)	LT-PDL
Brown Pelican (*Pelecanus occidentalis*)	LE
Piping Plover (*Charadrius melodus*)	LT
Whooping Crane (*Grus americana*)	LE
Mammals	
West Indian Manatee (*Trichechus manatus*)	LE
Reptiles	
Atlantic Hawksbill Sea Turtle (*Eretmochelys imbricata*)	LE
Green Sea Turtle (*Chelonia mydas*)	LT
Kemp's Ridley Sea Turtle (*Lepidochelys kempii*)	LE
Leatherback Sea Turtle (*Dermochelys coriacea*)	LE
Loggerhead Sea Turtle (*Caretta caretta*)	LT

Table A.7. Federally Listed Endangered and Threatened Species in Harris County, Texas

Species	**Status**
Amphibians	
Houston Toad (*Bufo houstonensis*)	LE
Birds	
American Peregrine Falcon (*Falco peregrinus anatum*)	LE
Arctic Peregrine Falcon (*Falco peregrinus tundrius*)	E/SA
Attwater's Greater Prairie-Chicken (*Tympanuchus cupido attwateri*)	LE
Bald Eagle (*Haliaeetus leucocephalus*)	LT-PDL
Brown Pelican (*Pelecanus occidentalis*)	LE
Piping Plover (*Charadrius melodus*)	LT
Whooping Crane (*Grus americana*)	LE
Reptiles	
Atlantic Hawksbill Sea Turtle (*Eretmochelys imbricata*)	LE
Green Sea Turtle (*Chelonia mydas*)	LT
Kemp's Ridley Sea Turtle (*Lepidochelys kempii*)	LE
Leatherback Sea Turtle (*Dermochelys coriacea*)	LE
Loggerhead Sea Turtle (*Caretta caretta*)	LT
Vascular Plants	
Texas prairie dawn (*Hymenoxys texana*)	LE

Table A.8. Federally Listed Endangered and Threatened Species in Jefferson County, Texas

Species	**Status**
Birds	
Piping Plover (*Charadrius melodus*)	LT
American Peregrine Falcon (*Falco peregrinus anatum*)	LE
Arctic Peregrine Falcon (*Falco peregrinus tundrius*)	E/SA
Brown Pelican (*Pelecanus occidentalis*)	LE
Interior Least Tern (*Sterna antillarum athalassos*)	LE
Mammals	
Red Wolf (*Canis rufus*)	LE
Reptiles	
Loggerhead Sea Turtle (*Caretta caretta*)	LT
Green Sea Turtle (*Chelonia mydas*)	LT
Leatherback Sea Turtle (*Dermochelys coriacea*)	LE
Atlantic Hawksbill Sea Turtle (*Eretmochelys imbricata*)	LE
Kemp's Ridley Sea Turtle (*Lepidochelys kempii*)	LE

Table A.9. Federally Listed Endangered and Threatened Species in Kenedy County, Texas

Species	**Status**
Birds	
Piping Plover (*Charadrius melodus*)	LT
Northern Aplomado Falcon (*Falco femoralis septentrionalis*)	LE
American Peregrine Falcon (*Falco peregrinus anatum*)	LE
Arctic Peregrine Falcon (*Falco peregrinus tundrius*)	E/SA
Brown Pelican (*Pelecanus occidentalis*)	LE
Interior Least Tern (*Sterna antillarum athalassos*)	LE
Mammals	
Ocelot (*Felis pardalis*)	LE
Jaguarundi (*Felis yaguarondi*)	LE
Black Bear (*Ursus americanus*)	T/SA
Reptiles	
Loggerhead Sea Turtle (*Caretta caretta*)	LT
Green Sea Turtle (*Chelonia mydas*)	LT
Leatherback Sea Turtle (*Dermochelys coriacea*)	LE
Atlantic Hawksbill Sea Turtle (*Eretmochelys imbricata*)	LE
Kemp's Ridley Sea Turtle (*Lepidochelys kempii*)	LE

Table A.10. Federally Listed Endangered and Threatened Species in Kleberg County, Texas

Species	**Status**
Birds	
American Peregrine Falcon (*Falco peregrinus anatum*)	LE
Arctic Peregrine Falcon (*Falco peregrinus tundrius*)	E/SA
Brown Pelican (*Pelecanus occidentalis*)	LE
Interior Least Tern (*Sterna antillarum athalassos*)	LE
Northern Aplomado Falcon (*Falco femoralis septentrionalis*)	LE
Piping Plover (*Charadrius melodus*)	LT
Mammals	
Jaguar (*Panthera onca*)—extirpated	LE
Jaguarundi (*Felis yaguarondi*)	LE
Ocelot (*Felis pardalis*)	LE
Reptiles	
Atlantic Hawksbill Sea Turtle (*Eretmochelys imbricata*)	LE
Green Sea Turtle (*Chelonia mydas*)	LT
Kemp's Ridley Sea Turtle (*Lepidochelys kempii*)	LE
Leatherback Sea Turtle (*Dermochelys coriacea*)	LE
Loggerhead Sea Turtle (*Caretta caretta*)	LT
Vascular Plants	
Black-laced cactus (*Echinocereus reichenbachii var. albertii*)	LE
South Texas ambrosia (*Ambrosia cheiranthifolia*)	LE

Table A.11. Federally Listed Endangered and Threatened Species in Matagorda County, Texas

Species	**Status**
Birds	
Piping Plover (*Charadrius melodus*)	LT
Peregrine Falcon (*Falco peregrinus*)	E/SA
American Peregrine Falcon (*Falco peregrinus anatum*)	LE
Arctic Peregrine Falcon (*Falco peregrinus tundrius*)	E/SA
Whooping Crane (*Grus americana*)	LE
Bald Eagle (*Haliaeetus leucocephalus*)	LT
Brown Pelican (*Pelecanus occidentalis*)	LE
Interior Least Tern (*Sterna antillarum athalassos*)	LE
Mammals	
Red Wolf (*Canis rufus*)	LE
Ocelot (*Felis pardalis*)	LE
West Indian Manatee (*Trichechus manatus*)	LE
Black Bear (*Ursus americanus*)	T/SA
Reptiles	
Loggerhead Sea Turtle (*Caretta caretta*)	LT
Green Sea Turtle (*Chelonia mydas*)	LT
Leatherback Sea Turtle (*Dermochelys coriacea*)	LE
Atlantic Hawksbill Sea Turtle (*Eretmochelys imbricata*)	LE
Kemp’s Ridley Sea Turtle (*Lepidochelys kempii*)	LE

Table A.12. Federally Listed Endangered and Threatened Species in Nueces County, Texas

Species	**Status**
Birds	
American Peregrine Falcon (*Falco peregrinus anatum*)	LE
Arctic Peregrine Falcon (*Falco peregrinus tundrius*)	E/SA
Brown Pelican (*Pelecanus occidentalis*)	LE
Eskimo Curlew (*Numenius borealis*)	LE
Piping Plover (*Charadrius melodus*)	LT
Whooping Crane (*Grus americana*)	LE
Mammals	
Jaguarundi (*Felis yaguarondi*)	LE
Ocelot (*Felis pardalis*)	LE
Reptiles	
Atlantic Hawksbill Sea Turtle (*Eretmochelys imbricata*)	LE
Green Sea Turtle (*Chelonia mydas*)	LT
Kemp's Ridley Sea Turtle (*Lepidochelys kempii*)	LE
Leatherback Sea Turtle (*Dermochelys coriacea*)	LE
Loggerhead Sea Turtle (*Caretta caretta*)	LT
Vascular Plants	
South Texas ambrosia (*Ambrosia cheiranthifolia*)	LE
Slender rushpea (*Hoffmannseggia tenella*)	LE

Table A.13. Federally Listed Endangered and Threatened Species in Orange County, Texas

Species	**Status**
Birds	
Piping Plover (*Charadrius melodus*)	LT
American Peregrine Falcon (*Falco peregrinus anatum*)	LE
Arctic Peregrine Falcon (*Falco peregrinus tundrius*)	E/SA
Brown Pelican (*Pelecanus occidentalis*)	LE
Interior Least Tern (*Sterna antillarum athalassos*)	LE
Mammals	
Red Wolf (*Canis rufus*)	LE
Black Bear (*Ursus americanus*)	T/SA
Louisiana Black Bear (Ursus americanus luteolus)	LT

Table A.14. Federally Listed Endangered and Threatened Species in San Patricio County, Texas

Species	**Status**
Birds	
Piping Plover (*Charadrius melodus*)	LT
American Peregrine Falcon (*Falco peregrinus anatum*)	LE
Arctic Peregrine Falcon (*Falco peregrinus tundrius*)	E/SA
Whooping Crane (*Grus americana*)	LE
Brown Pelican (*Pelecanus occidentalis*)	LE
Interior Least Tern (*Sterna antillarum athalassos*)	LE
Mammals	
Red Wolf (*Canis rufus*)—extirpated	LE
Ocelot (*Felis pardalis*)	LE
Jaguarundi (*Felis yaguarondi*)	LE

Table A.15. Federally Listed Endangered and Threatened Species in Willacy County, Texas

Species	**Status**
Birds	
Piping Plover (*Charadrius melodus*)	LT
Northern Aplomado Falcon (*Falco femoralis septentrionalis*)	LE
American Peregrine Falcon (*Falco peregrinus anatum*)	LE
Arctic Peregrine Falcon (*Falco peregrinus tundrius*)	E/SA
Brown Pelican (*Pelecanus occidentalis*)	LE
Interior Least Tern (*Sterna antillarum athalassos*)	LE
Mammals	
Ocelot (*Felis pardalis*)	LE
Jaguarundi (*Felis yaguarondi*)	LE
West Indian Manatee (*Trichechus manatus*)	LE
Reptiles	
Loggerhead Sea Turtle (*Caretta caretta*)	LT
Green Sea Turtle (*Chelonia mydas*)	LT
Leatherback Sea Turtle (*Dermochelys coriacea*)	LE
Atlantic Hawksbill Sea Turtle (*Eretmochelys imbricata*)	LE
Kemp's Ridley Sea Turtle (*Lepidochelys kempii*)	LE