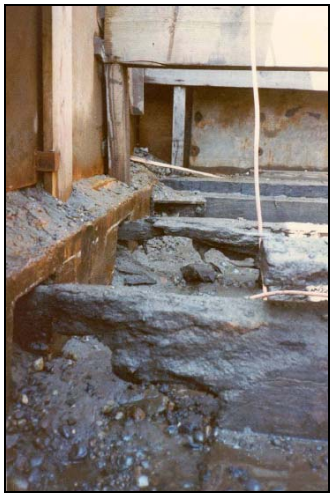
SECTION 905(b) (WRDA 1986) ANALYSIS

Elliott Bay, Washington

Shore Protection and Storm Damage Reduction



AUGUST 2003

ELLIOT BAY, WASHINGTON
SECTION 905(b) (WRDA 86) ANALYSIS

1. STUDY AUTHORITY

This Section 905(b) (WRDA86) Analysis was prepared as an initial response to the Committee on Transportation and Infrastructure, U.S. House of Representatives, House Resolution 2704, September 25, 2002, which reads as follows:

> *Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, That the Secretary of the Army is requested to review the Comprehensive Study of Water and Related Land Resources for Puget Sound and Adjacent Waters, State of Washington, dated 1971, and other pertinent reports to determine whether modification and recommendations contained therein are advisable at the present time in the interest of storm damage prevention, shoreline protection, environmental restoration and protection, and related purposes in Elliott Bay, Washington, including the rehabilitation of the Alaskan Way seawall.*

Funds in the amount of $100,000 were appropriated in Fiscal Year 2003 to conduct the reconnaissance phase of the study.

2. STUDY PURPOSE

The purpose of the reconnaissance phase study is to determine if there is a Federal (Corps) interest in participating in a cost shared feasibility phase study to provide storm damage prevention, shoreline protection, environmental restoration and protection, and related purposes improvements to Elliott Bay and the Alaskan Way Seawall. In response to the study authority, the reconnaissance study was initiated on 14 April 2003. The reconnaissance study has resulted in the finding that there is a Federal interest in initiating a feasibility phase study of the Alaskan Way Seawall. The purpose of this Section 905(b) Analysis is to document the basis for this finding and establish the scope of the feasibility phase. As the document that establishes the scope of the feasibility study, the Section 905(b) Analysis is used as the chapter of the Project Management Plan that presents the reconnaissance overview and formulation rationale.

3. LOCATION OF STUDY, NON-FEDERAL SPONSOR AND CONGRESSIONAL DISTRICTS

The study area is along the Elliott Bay shoreline, within the central business district of the city of Seattle, Washington. Seattle is a major port city for trans-Pacific and European trade. The Port of Seattle is the fifth largest (in dollar value) container port in the United States handling $32 billion worth of products each year. The seawall extends for a distance of approximately 7,900 feet. The southern terminus of the wall abuts the Port of Seattle bulkheads and falls in the vicinity of Pier 48. The northern terminus of the seawall ends at the southern end of Myrtle Edwards Park, where it abuts natural slopes that have

been armored with heavy rip-rap. The wall is interrupted in places by fill, so that the total length of wall structure is actually somewhat less than 7,900 feet. The non-Federal sponsor for the feasibility phase of the study is the City of Seattle. The study area lies entirely within the Washington State 7th Congressional District, Jim McDermott (D). The letter of intent from the City of Seattle is enclosed in Appendix A. Maps and photographs from the project area are enclosed in Appendix B.

4. PRIOR REPORTS AND PLANNED PROJECTS

A. LOCAL REPORTS AND PROJECTS

(1) Local Reports

City of Seattle and Washington State Department of Transportation (WSDOT), with support from Federal Highway Administration (FHA), have prepared several reports regarding the existing condition, problems, and potential solutions for issues surrounding the seawall. These reports explain the history of the seawall, how it has been damaged over time, detailed information regarding its existing degradation, and potential damages to public infrastructure and other facilities. These reports, as listed below, served as the basis for determining Federal interest in pursuing a cost-shared feasibility phase study.

Screening of Seawall Concepts, March 2002.

This report provides options for replacing or retrofitting the existing Alaskan Way Seawall with structures that are capable of resisting the estimated loads that may occur due to an earthquake that has a 10 percent probability of being exceeded in 50 years, which is the current code specified earthquake. This report was prepared by a variety of consulting firms, led by Parsons, Brinckerhoff, Quade & Douglas, Inc., for the City of Seattle and WSDOT.

Alaskan Way Seawall Design Report, July 2002.

Of the 50 different variations of concepts originally identified, three build options were selected for conceptual design and are the focus of this report. These three options are the Rebuild, the Wharf, and the Frame. Summary descriptions for these three options follow along with a summary of the No Build / No Action Option. This report was prepared by a variety of consulting firms, led by Parsons, Brinckerhoff, Quade & Douglas, Inc., for the City of Seattle and WSDOT.

Alaskan Way Seawall Wave Study, September 2002.

This report summarizes the results of engineering analysis and recommendations developed in completion of the Alaskan Way Seawall Wave and Sediment Transport Design Criteria project. This is the second report prepared on wave forces for the Alaskan Way Seawall. The first report, "Seattle Seawall Replacement Existing Data for Development of Design Criteria," was submitted on 15 May 2002 is Appendix A to the Wave study report. The first report provided a review and summary of existing oceanographic and coastal engineering data to form a design basis for the City of Seattle, Alaskan Way Viaduct and seawall project. The data included tidal datum, water surface elevations, wind speed and direction, bathymetry, deepwater wave statistics, and sediment types. The current report includes the results of the engineering analysis to

obtain the design wave parameters at the project site, wave forces and run-ups on the seawall structure, rock revetment design recommendations, and potential for scouring at the toe of the vertical wall where placement of toe protection is not anticipated. This report was prepared by a variety of consulting firms, led by Parsons, Brinckerhoff, Quade & Douglas, Inc., for the City of Seattle and WSDOT.

The Analysis of Existing Alaskan Way Seawall, January 2003.
This report assesses the structural performance of several sections of the Alaskan Way seawall for three different levels of seismic events. The assessment of seismic performance includes an assessment of liquefaction potential at the site and its effect on the global stability of the soil mass that the seawall is built on. This report was prepared by a variety of consulting firms, led by Parsons, Brinckerhoff, Quade & Douglas, Inc., for the City of Seattle and WSDOT.

(2) Local Projects
The most tightly linked local project to the seawall study is the current analysis of the Alaskan Way Viaduct, conducted by the City of Seattle, in conjunction with WSDOT, FHA and other entities. Damage to the viaduct from the Nisqually earthquake in February 2001 underscored the seismic vulnerability of the Alaskan Way Viaduct (SR99) and created widespread recognition of the urgent need to retrofit or replace the structure. This recognition of instability in the viaduct led to investigations into the structural stability of the seawall. The viaduct runs parallel to the seawall, within the seawall study area, and the some of the alternatives being proposed for viaduct construction utilize the seawall for infrastructure support. The development of seawall study alternatives will be closely coordinated with the Alaskan Way Viaduct project through the City of Seattle and WSDOT, through all phases of Alaskan Way seawall project development.

In congruence with the development of the project, the Elliott Bay shoreline is under redevelopment for improved connectivity with the downtown area by the City of Seattle. The city is currently developing a comprehensive Central Waterfront Plan, encompassing the seawall study area. This involves creating a vital, active waterfront, retaining and enhancing an efficient transportation corridor/regional transportation hub, realizing the waterfront's enormous economic potential and enhancing the quality of the natural shoreline environment and improving aquatic habitat for salmon and other sea life. Currently, the city is in the planning phase and is collecting public input to inform design recommendations.

B. CORPS EXISTING PROJECTS AND STUDIES

There are no existing Corps projects that have potential for modification in the study area. One Corps study is in the same study area as the Alaskan Way seawall study.

BPuget Sound Nearshore Marine Habitat Restoration Study

The PSNS is examining the degraded habitat within the Nearshore region in particular looking for way to restore highly impacted shorelines similar to those along the seawall. Coordination between these two studies will need to occur to ensure non-duplication of efforts (i.e. surveys, mapping, environmental analysis), and that recommendation presented are consistent, or at least not contradictory, to the objectives of the other study.

5. PLAN FORMULATION

During a study, six planning steps that are set forth in the Water Resource Council's Principles and Guidelines are repeated to focus the planning effort and eventually to select and recommend a plan for authorization. The six planning steps are: 1) specify problems and opportunities, 2) inventory and forecast conditions, 3) formulate alternative plans, 4) evaluate effects of alternative plans, 5) compare alternative plans, and 6) select recommended plan. The iterations of the planning steps typically differ in the emphasis that is placed on each of the steps. In the early iterations, those conducted during the reconnaissance phase, the step of specifying problems and opportunities is emphasized. That is not to say, however, that the other steps are ignored since the initial screening of preliminary plans that results from the other steps is very important to the scoping of the follow-on feasibility phase studies. The sub-paragraphs that follow present the results of the initial iterations of the planning steps that were conducted during the reconnaissance phase. This information will be refined in future iterations of the planning steps that will be accomplished during the feasibility phase.

A. THE FEDERAL OBJECTIVE

1) The Federal objective of water and related land resources planning is to contribute to national economic development consistent with protecting the nation's environment, pursuant to national environmental statures, applicable executive orders, and other Federal planning requirements. Contributions to National Economic Development (NED) are increases in the net value of the national output of goods and services, expressed in monetary units. Contributions to NED are the direct net benefits that accrue in the planning area and the rest of the nation.

2) The Corps has added a second national objective for Ecosystem Restoration in response to legislation and administration policy. This objective is to contribute to the nation's ecosystems through ecosystem restoration, with contributions measured by changes in the amounts and values of habitat.

B. PUBLIC CONCERNS

A number of public concerns have been identified during the course of the reconnaissance study. Initial concerns were expressed in the study authorization. Additional input was received through coordination with the sponsor, and some initial coordination with other agencies. The public concerns that are related to the

establishment of planning objectives and planning constraints can be broken into three categories; economic issues, social impacts, and environmental concerns.

1) Economic Issues –Maintain and protect the existing shoreline along Elliot Bay Waterfront. The waterfront area supports a dense and highly developed portion of the city that includes major transportation corridors such as the Alaska Way Viaduct, passenger and vehicle ferry terminals and rail lines; commercial and non-commercial activities include retail, wholesale, museums, tourist attractions, a fire station, coast guard facility, and high density residential housing; and public utilities, water, electric, gas/petroleum, steam communications, sanitary sewers and storm water drainage. Disruption of any of these systems at the very least could cause minor inconvenience to those effected to a shut down of the central downtown business district for an undetermined amount of time.

2) Social Impacts – Safety (access, egress, catastrophic failure), tribal interests (usual and accustomed areas), cultural/historical (buildings, structures, monuments), change in use of waterfront, multiple stakeholders, and complex issues.

3) Environmental Concerns – These issues include human health and environmental impacts from exposure to potentially contaminated materials behind the seawall, impacts to species listed under the Endangered Species Act, impacts to aquatic resources, including aquatic habitat adjacent to the seawall, construction impacts to water quality and habitat, limited availability of suitable habitat within Elliot Bay, and environmental impacts related to catastrophic failure of the seawall and the public facilities and infrastructure located landward of the seawall.

C. PROBLEMS AND OPPORTUNITIES: The evaluation of public concerns often reflects a range of needs, which are perceived by the public. This section describes these needs in the context of problems and opportunities that can be addressed through water and related land resource management. For each problem and opportunity, the existing conditions and the expected future conditions are described, as follows:

(1) *The seawall is experiencing significant decay and deterioration, leading to structural instability along the Seattle waterfront and central business district.* The current seawall consists primarily of four different types of walls and extends for approximately 7,900 feet along Elliot Bay between Washington Street, southern terminus, and Bay Street, northern terminus. The southern section of the seawall consists of two types, which are an unreinforced concrete gravity wall with supporting timber relieving platform and a pile-supported concrete sidewalk. The gravity wall and timber platform were constructed in 1916 and various types of the pile-supported concrete sidewalk were constructed in 1916, 1964, with a significant replacement in 1987. The 1964 and 1987 construction replaced most of the original 1916 portion. The rest of the seawall extending from Madison Street to Bay Street consists of Type A and Type B seawall constructed in 1934. The Type A seawall is approximately 5,300 feet long and the Type B seawall section is approximately 1,400 feet long. Both the Type A and Type B seawall sections consist of a pile-supported relieving platform attached to the seawall, which provides lateral support to the seawall and support for the roadway loading and fill above it. The Type B seawall

is taller and wider than the Type A seawall and for both types of walls, the pile-supported relieving platform is constructed of untreated timber. All seawall sections have loose, saturated, liquefiable fill material placed behind them that consists primarily of very loose to medium dense sand with some amounts of gravel and silt and small amounts of clay.

City maintenance records of the existing seawall reveal that there has been extensive and continual maintenance and repair of the seawall. Marine borers have extensively decayed the timber relieving platform behind the precast concrete walls. The most significant areas with marine borer damage are along the Type B wall. This is due to the holes in the Type B steel sheet pile wall caused by corrosion. The Type A wall platform was recently discovered to also have severe damage in areas caused by marine borers, which is contrary to the original assumption that the Type A wall was secure against marine borer assault. The Type A wall was thought to be secure because the concrete and sheet pile construction extended below the mudline forming a barrier between the fill and seawater. After discovering the unknown damage behind the Type A wall, additional subsurface explorations were performed. Geoprobe explorations indicated that there is marine borer damage to some extent on the deck boards and cap beams that make up the relieving platform in all test pits. Based on the explorations, it is estimated that up to one-third of the seawall has sustained marine borer damage.

The Type B steel sheet pile wall first began to contain holes due to corrosion in 1947. Tidal and wave action proceeded to wash fill out from behind the wall leaving voids that marine borers used to access the timber relieving platforms, which provides overturning support and supports the roadbed and fill above. In 1954, Alaskan Way failed at Clay Street due to fill loss and damage from marine borers. This area was repaired along with other voids that were backfilled. This failure occurred within only 20 years of Type B wall construction. In 1956, a cathodic protection system was installed at Clay Street along the Type B steel sheet pile wall with the rest of the Type B wall receiving cathodic protection in 1961. The cathodic protection system reduced the rate of corrosion, but did not eliminate all corrosive effects and new holes continued to appear. Another large void was found in 1962 near University Street and required filling to prevent roadway failure. This area also had damage from marine borers. In 1973, the cathodic protection system was upgraded and continues to be annually inspected, which improved the protection along the wall. But, the system has not blocked all corrosion, which is illustrated by the additional voids found in 1974 and 1979 that required more fill maintenance to avoid damage to the existing utilities and roadway. In 1982, a site condition survey was performed, part of which determined more damage due to marine borers. Timber, making up the relieving platform at Clay Street, no longer existed. Subsequently, in 1985, the timber relieving platform at Clay Street was rebuilt and an "Ekki" wood facing was constructed on the Type B steel sheet pile wall to retain the fill as a barrier between the timber pilings and marine borers in the seawater. Repairs to the "Ekki" wood facing were performed in 1999. In 1987, the structural sidewalks south of Madison were rebuilt with better slope protection, following the recommendations of the 1979 *'Alaskan Way Promenade and Seawall Guide Plan Study'*. Test pits, performed in 2001, indicated

severe marine borer damage to the Type A relieving platform near Waterfront Park and test pits in 2002 also indicated additional marine borer damage in all test pits.

The seawall structure is at the end of its design life of 75 years and will require continual maintenance to remain functional. If the marine borer damage is not repaired, the walls are expected to be instable and potentially fail at key areas even during low-energy earthquakes. As constructed, the existing seawall was not designed for seismic loads and cannot meet American Association of State highway and Transportation Officials (AASHTO) current seismic standards of 10 in 50 years. A large seismic event could potentially displace the liquefiable soils that can exert pressures up to three times the original design pressures the structure was constructed to withstand, leading to failure. Failure could be limited to isolated sections or could be very extensive. Without extensive and continual repair, further deterioration of the existing seawall will lead to rendering the structure incapable of supporting current static loads. Without extensive structural rebuild or replacement, the existing seawall will continue to be incapable of supporting current seismic design loads.

(2) *Seawall structural instability is putting a tremendous amount of public and private infrastructure and development at risk of damage due to wave and tidal erosion, and hence potential for undermining and collapse.* Assuming a probable failure scenario cause by damage from marine borers, wave and tidal action and age, potential damages threaten major transportation corridors, underground utility corridors, commercial establishments and multi-family residential structures. Estimated damages from a major failure of the seawall could be in excess of a billion dollars. The estimated remaining life of the seawall is between 10 to 15 years. Damage estimates presented in this analysis assume a failure would occur in year thirteen. Annualized routine and major maintenance to the seawall over the last seventeen years amount to $800,000. Additionally, the safety and welfare of thousands of people would be jeopardized.

(a) Structures and Contents - The study area most likely to be impacted is a highly developed, concentrated mixed-use area. Failure of the seawall is expected to first occur between Union and University Streets and between Bay and Clay Streets making up approximately 25% the seawall length. The estimated study area has about one hundred buildings with an estimated value, including contents, of $937.5 million. Failure of the seawall could potentially cause substantial damages to the structures and contents. The affected area has many retail, wholesale and other types of commercial establishments plus, high rise residential developments, private offices, government offices, including the Seattle Federal building and fire and Coast Guard stations.

(b) Transportation Corridor - One of the major north/south corridors in the City of Seattle is State Route 99, more commonly known as the Alaskan Way Viaduct. State Route 99 runs adjacent to Alaskan Way, parallel to the seawall and is structurally supported by the seawall. The viaduct was built 49 years ago and was designed to carry 65,000 vehicles per day. Traffic study data collected by the City of Seattle and WSDOT approximates the two-mile long viaduct carries 110,000 vehicles on average each day, one quarter of the

north-south traffic through downtown Seattle. Should the seawall fail, the viaduct would be closed. Freight haulers, commercial vehicles and commuters, at a minimum, would shift to alternate routes on surface streets or freeways that presently function above designed capacity, adding substantially to time and travel costs.

1) Surface Streets and Piers

Alaskan Way is the surface street running parallel to the seawall and carrying approximately 9,000 vehicles per day. Three to six percent of the vehicles are commercial trucks of all sizes. Alaskan Way allows direct vehicle access to the shops and businesses along the piers. Tourists and locals residents are attracted to the waterfront pier area shops, restaurants, Canadian ferries and charter boat services. If the seawall failed, Alaska Way would be closed to all vehicle and pedestrian traffic, time and travel costs would increase, causing many of the 9,000 daily vehicles to find alternate routes via surface streets and freeways.

2) Ferry Terminal

The Washington State Ferry system's Coleman ferry terminal is located in the project footprint, connecting Bremerton and Bainbridge islands to Seattle. An average of more than 26,000 passengers pass through the terminal daily. Vehicle and passenger ferries and passenger only ferries dock at the Coleman terminal. Should the seawall fail the Coleman terminal would be closed and traffic re-routed to Edmonds ferry terminal, causing congestion and adding to travel and time delays. Tourist ferries going to and from Canada and cruise ships also dock at facilities along the seawall.

3) Railroads

The north/south Burlington Northern rail line runs parallel and east of Alaskan Way, and is the major local rail line that connects the city and the Port of Seattle to the north and east. Failure of the seawall would cause the closure of the rail line and would require rerouting of trains causing significant delays and congestion along the only remaining alternate rail line linking Seattle to the midwest and east.

4) Public Utilities

Buried beneath the Alaskan Way are public utility corridors, which provide service and connect the city. It is predicted that if the seawall fails, major portions of the utilities that connect and service the downtown core and surrounding areas would be disrupted for a minimum of a several days to weeks. The following systems are known to be running under Alaskan Way: Electricity, water, steam, and communication (telephone, cable, broadband, fiber optics) lines, gas/petroleum lines, sanitary sewers, storm drains and combined drainage systems. At least 20 companies have communication lines under Alaskan Way, ranging from fiber optic to copper wire lines.

(3) *The natural environment along the waterfront has been highly altered.* Prior to European-American settlement, the Seattle shoreline was part of the large natural estuarine complex of the Duwamish River and Elliott Bay. The area consisted of extensive mudflats with fringing marshes and a complex freshwater riparian community. The area likely supported a variety of plant and animal species, including a substantial migratory salmonid population. Bortleson et al (1980) estimates that the Duwamish

Estuary and the shorelines of Elliott Bay (current City of Seattle Waterfront) supported approximately 3,763 acres of mudflat and tidal salt marsh 150 years ago. The development of the City of Seattle resulted in the lost of virtually all of these habitats as well as the loss of the entire riparian habitat. All of the original Elliott Bay shoreline of the City of Seattle has been lost or significantly altered through the extensive placement of fill materials and the construction of the existing seawall. Functions associated with the historic Elliott Bay/Duwamish estuary include migratory and resident bird resting, feeding, and rearing habitat, migratory and resident fish resting, feeding, and rearing habitat, food chain support, organic input to the marine ecosystem, and sediment trapping (water quality). Functions associated with the existing habitat include migratory and resident bird resting and feeding, resident fish feeding, and migratory fish passage (including listed species under the Endangered Species Act). The functional capacity of the Elliott Bay/Duwamish Estuary aquatic complex has been severely diminished and continues to incur adverse impacts from development and industrial pollution. Elliott Bay and the Duwamish Estuary currently support commercial and industrial facilities.

(4) *Need for implementation methodology for the multiple comprehensive plans for Seattle waterfront*. Elliott Bay serves as the center of multiple projected improvements in the near future. These projects include the development of the Alaskan Way Viaduct project and the comprehensive Central Waterfront Plan Coordinating the Alaskan Way seawall study with these improvements presents an opportunity to gain increased economic, ecological, social benefits and/or reduce project cost. Waterfront redevelopment has interest from local and regional stakeholders for ecologically improving the shoreline habitat, particularly to benefit ESA-listed Chinook Salmon, which migrate along the shoreline of Elliott Bay. These interests include innovative reconstruction of the seawall to promote environmental sustainability in Elliott Bay.

D. PLANNING OBJECTIVES

The national objectives of National Economic Development and National Ecosystem Restoration are general statements and not specific enough for direct use in plan formulation. The water and related land resource problems and opportunities identified in this study are stated as specific planning objectives to provide focus for the formulation of alternatives. These planning objectives reflect the problems and opportunities and represent desired positive changes in the without project conditions. The planning objectives are specified as follows:

(1) Reduce storm, erosion, and deterioration damages along the Elliott Bay shoreline study area over a 50-years period of analysis.

(2) Reduce threats of damages to public utilities, facilities, infrastructure, transportation to levels consistent with existing and projected uses or the study area.

(3) Develop solutions that are, to the greatest extent practicable, consistent with other local, regional, and Federal activities including ESA restoration.

E. PLANNING CONSTRAINTS

Unlike planning objectives that represent desired positive changes, planning constraints represent restrictions that should not be violated or add to project complexity. The planning constraints identified in this study are as follows:

(1) Compliance and communication with City of Seattle's developing land use plans, specifically the Alaskan Way Viaduct Project, redesigning the major waterfront thoroughfare, and the Central Waterfront Plan, accommodating for new, future uses of the waterfront.

(2) Applicable Executive Orders, Statutes, Policies and Regulations.
National Environmental Policy Act
National Historic Preservation Act
Clean Water Act
Rivers and Harbors Act
Endangered Species Act
Coastal Zone Management Act
Clean Air Act
Native American Grave Protection and Repatriation Act
Comprehensive Environmental Response, Compensation, and Liability Act
Resource Conservation and Recovery Act
Executive Order 12898 Action for Addressing Environmental Justice in Minority and Low Income Populations
Executive Order 11990 Protection of Wetlands
Executive Order 11988 Floodplain Management
Executive Order 13175 Consultation and Coordination with Indian Tribal Governments
ER 200-2-2, Procedures for Implementing National Environmental Policy Act
ER 1105-2-100, Planning Guidance Notebook

(3) Real estate ownership is diverse and complicated.

(4) Solution/project costs are in the hundreds of millions.

(5) Suitable levels of access to shoreline must be maintained.

(6) Suitable levels of through transportation (Viaduct, Alaskan Way, and Rail Road).

(7) Study area is a center of cultural significance to the City of Seattle and public.

(8) Potential environmental impacts including the involvement with natural and Hazardous, Toxic and Radioactive Waste (HTRW).

F. MEASURES TO ADDRESS IDENTIFIED PLANNING OBJECTIVES

A management measure is a feature or activity at a site, which address one or more of the planning objectives. A wide variety of measures were considered, some of which were found to be infeasible due to technical, economic, or environmental constraints. Each measure was assessed and a determination made regarding whether it should be retained in the formulation of alternative plans. The descriptions and results of the evaluations of the measures considered in this study are presented below:

(1) No Action - The no action measure consists of continuing to repair and maintain the existing seawall. Without seismic events, the seawall could potentially be repaired for another 25 years. As the structure continues to age, the cost of repairs will likely increase considerably. There are several areas along the seawall that must be considered when looking into continued repair and maintenance of the seawall. The riprap toe along the entire length of the seawall requires maintenance. The steel sheet pile of the existing Type B seawall has undergone considerable corrosion in the past. Cathodic protection has decreased the rate of corrosion, but it is continuing. Holes in the steel sheet pile are covered with an "Ekki" wood retaining system that is prone to damage from impact by debris in Elliott Bay. When the "Ekki" wood structure is breached in areas with past corrosion, the marine borers continue to destroy the timber-relieving platform, which is a key component of portions of the seawall's structural integrity. Due to previous and continual damage by marine borers to the timber-relieving platform, the platform will continue to need repair. Damage to the platform is hard to locate due to its location under Alaskan Way, which creates the potential to overlook areas in need of repair until visible from the surface failure in the way of settlement or sinkholes. Even with repairs, the existing seawall is only capable of resisting static loads and possibly very low-level earthquakes without complete structural failure. If a substantial seismic event occurred, the existing seawall would not be able to withstand the seismic loads placed upon it. Depending on the severity of a seismic event, the seawall and surrounding structures and utilities would sustain various levels of failure ranging from small amounts of settlement, isolated sections of seawall failure, utility damage, to catastrophic failure of the seawall and supported structures and utilities.

(2) Non-Structural – Non-structural activities that typically include removal or relocation of structures are not likely to be applicable for a solution to the issues along the waterfront, though there may be certain segments where removal or naturalization of shoreline is the most appropriate solution. Non-structural measures that may apply could be related to revisions to shoreline management and usage within the project area. Any change to how the shoreline is managed would be implemented on a local, county, or state level depending upon the appropriate jurisdictional boundaries.

(3) Structural – The existing seawall condition is deteriorated and continually requires maintenance to sustain static loads and cannot resist seismic loads. There are several measures for a new seawall design. The existing seawall measures include rebuild or replacement of the existing seawall in order meet current structural and seismic criteria. All replacement measures require expansion joints to allow for expected movement of the seawall structure during a seismic event.

(a) Rebuild Measure - The rebuild measure consists of soil stabilization by jet grouting under the existing relieving platform and drilled shaft concrete secant pile walls. The combination of the two techniques will support static loads and is meet current seismic standards. Jet grouting is a mixture of existing soils and a stabilizer, commonly cement. Multiple columns of grout are pumped into the ground and spaced closely together to create areas with enhanced strength that encase areas of unsatisfactory fill material. The

concrete secant pile wall forms the new barrier between Elliott Bay and the fill material behind the wall. It is constructed of repetitively spaced drilled reinforced and unreinforced concrete shafts connected together to form the wall. Under this measure, there is potential to repair sections of the existing Type A seawall, eliminating the need for the concrete secant pile wall in this section. In this measure, the existing seawall can remain or be removed, but if it remains, the Type B sheet pile wall would need replacing with a concrete wall to resist wave forces. Even though the existing seawall could remain because it would no longer be a supporting structure, during a seismic event, there would be potential for the remaining seawall to fail, which could cause some localized damage simply due to the structure failing. The rebuild measure would require excavation to locate existing utilities for jet grouting purposes and only minimal utility relocation for the construction of the drilled secant pile walls.

(b) Frame Measure - The frame measure consists of two walls connected by a T-beam deck. This measure will support static loads and is meet to current seismic standards. Similar to the rebuild measure, the frame measure has a drilled shaft concrete secant pile wall located behind the existing seawall. The second wall is a bulkhead constructed of drilled shafts that is located behind the new secant pile wall and existing relieving platforms. The shafts making up the bulkhead are larger than the secant pile wall shafts, which are used to anchor the secant pile wall. The T-beam deck, consisting of multiple bulkhead cap beams, is located below the roadway surface to accommodate utilities and provides structural support for the secant wall and bulkhead. In this measure, the secant wall is connected to the existing seawall, but the existing seawall does not contribute to load bearing capacity. The remaining Type B sheet pile wall would need replacing with a concrete wall to resist wave forces. Even though the existing seawall could remain because it would no longer be a supporting structure, during a seismic event, there would be potential for the remaining seawall to fail, which could cause some localized damage simply due to the structure failing. The frame measure would require significant excavation to construct the new seawall and relocate utilities to a utilidor located above the bulkhead section of the seawall.

(c) Wharf Measure - The wharf measure requires the most extensive construction effort of all the measures, supports static loads, and would meet current seismic standards. It consists of removing the existing seawall, timber pilings, relieving platforms, and large amounts of soil behind the existing seawall and replacing it with a slurry wall constructed wharf bulkhead structure. The bulkhead would be located up to 65 feet east of the existing seawall location with piles driven to support the wharf structure. Pile cap beams to the bulkhead connect the piles and the pile cap beams support concrete pier deck panels upon which sidewalk and roadway are placed. Under this measure, existing utilities will be relocated to a utilidor located behind the wharf structure. This measure provides an increase in potential shoreline habitat due to the large amounts of fill removal and the wharf type structure, but the cost of this measure is the highest and there are environmental concerns associated with the extensive amounts of excavation and removal required.

(4) Additional Measures for Complete Alternatives - All alternatives plans will be evaluated for their compliance with existing Federal laws, policies, and regulations for protection and restoring the environment. In addition, all alternatives will be evaluated within a landscape perspective to assure minimization and avoidance of direct, indirect, and cumulative environmental impacts. Alternatives will consider beneficial features within any structural recommendations to enhance and/or restore the quality of the existing environment. Additional environmental restoration measures will also be considered, where applicable and practicable.

G. PRELIMINARY PLANS

Preliminary plans are comprised of one or more management measures that survived the initial screening. The descriptions and results of the evaluations of the preliminary plans that were considered in this study are presented below:

(1) No Action. The Corps is required to consider the option of "No Action" as one of the alternatives in order to comply with the requirements of the Corps planning regulations and those of the National Environmental Policy Act (NEPA). No Action assumes that no project would be implemented by the Federal Government or by local interests to achieve the planning objectives. No Action, which is synonymous with the Without Project Condition, forms the basis from which all other alternative plans are measured.

(2) Non-Structural – This plan would utilize only non-structural measures to reduce the potential damages in the project area.

(3) Seawall Alone – This plan would utilize the most feasible combination of structural measures to develop solutions.

(4) Seawall Integrated with Viaduct – This plan would utilize the most feasible combination of structural measures to develop solutions. In addition, certain portions of the seawall would be constructed to either be a part of or in support of the viaduct replacement. These features would likely be betterments.

(5) Seawall Integrated with Additional Measures – This plan would utilize the most feasible combination of structural measures to develop solutions. In addition, certain habitat enhancing features would be built into the seawall to create better environmental usage of the project area.

(6) Combination Measures – This plan would utilize appropriate portions of all measures to develop a solution.

H. CONCLUSIONS FROM THE PRELIMINARY SCREENING.

The preliminary screening of alternatives indicates include at least one alternative appears feasible. Plans that include structural replacement of the seawall done in concert with viaduct replacement and habitat improvement have the greatest potential for implementation. The potential reduced damages from the proposed actions would include structural, transportation, utility and environmental categories.

Structural Damages Estimate
Damage from a seawall failure to 25% of the buildings and contents were estimated in the study area at $234 million. Adjusting these damages to present value (discounted to 13-years) and annualizing at $5^{7/8}$ percent over 50 years results in average annual structures and content damages of $7.0 million.

Transportation Damages Estimate
Vehicle - If the seawall fails officials have stated the viaduct and Alaskan Way would be closed and a complete evaluation of the fill under Alaskan Way and permanent repairs or replacement of the seawall would have to be completed before reopening the viaduct or Alaskan Way. It was estimated this would take between one to three-years, for this estimate one year was assumed. Additional travel and time costs were estimated based on the following assumptions, there would be and average increase of ten miles per trip, and an average 1.5 hours added to each trip diverted from the viaduct and Alaskan Way. Most streets and freeways in and around the Seattle downtown core area handle traffic in excess to their design capacity. Estimated travel and time costs, for the average additional 119,000 vehicles per day funneling through downtown Seattle streets, for oneyear amounted to $1.4 billion. These damages, when adjusted to present value and annualized over 50 years amount to $41 million, on an average annual basis. This estimate does not reflect the impact on other drivers in the downtown area.

Vessels or Ferry Terminal (see pervious section, they should be in agreement. My suggestion is Ferry Terminal, but ultimately you rule.)- Should the seawall fail, the ferry and cruise ship facilities would be greatly affected. No other terminals in or around Seattle could accommodate the volume of traffic that Coleman terminal handles. Estimated time and travel costs were based on the assumption the terminal is out of service for 60 days. An average of 26,000 daily passengers would be forced to use alternate routes while temporary facilities are setup or repairs made to the Coleman ferry terminal. It was assumed passengers from Bremerton would drive and take an additional two-hours over and above the normal commute time. Bainbridge passengers were assumed to drive to Kingston, catch a ferry to Edmonds and drive south to Seattle, taking 1.5 hours longer, on average, over the normal commute time. Walk-ons were assumed to follow the same routes as above but would carpool. Based on these assumptions, additional travel and time for one year amounted to about $68 million. When adjusted to present value and annualized, this amounted to $2.0 million.

Rail - No data was available to estimate damages.

In total, transportation related damages accounted for in this analysis include travel and time costs for pedestrian and vehicular traffic on the viaduct, Alaskan Way the ferry. . The estimated additional travel and time costs for users of the viaduct and Alaskan Way and ferry users amounted to an annualized cost of $43 million. This estimate does not include rerouting railroad service or the overall impacts to traffic in the central downtown core area.

Utilities Damages Estimate
Replacement of all the utility systems under Alaskan Way was estimated at about $8,300 per-foot. Estimated damages from a 25% seawall failure amount to $15 million and when adjusted to present value and annualized, amounts to $443,000. Annualized repair costs of damaged systems, regulatory fines related to the release of untreated sewage, gas/petroleum spills or other contaminates were not included in this estimate of these damages.

Total Economic Damages
The aggregated amount of all damage categories that were quantified is $50.4 million on an average annual basis. Damage categories do not include emergency and clean-up costs, time and travel expenses to re-route train traffic, structural demolition and removal costs, or full travel and time cost analysis of all central downtown traffic impacted by the additional viaduct traffic. Inclusion of these damage categories will increase the estimated annualized damages. During the feasibility phase all damage categories will be fully analyzed and quantified.

Environmental Damages
Potential environmental damages in case seawall failure are direct, indirect, and cumulative impacts to aquatic habitat, including habitats that provide support for species listed under the Endangered Species Act, impacts to historical and cultural resources, aesthetic impacts, recreation impacts. The contaminated sediments within the fill behind the seawall pose a risk of uncontrolled dispersion in a seawall failure scenario.
Environmental Opportunities
Potential environmental measures can be attained through mitigation measures or through the reconstruction of the seawall. Potential measures to mitigate adverse effects include avoidance and minimization of impacts through project design, construction design and implementation; the creation, enhancement and/or restoration of aquatic habitat within Elliott Bay and the Duwamish Estuary for any unavoidable aquatic resource impacts; and incorporation of aesthetic and recreational features within project design. Opportunities also exist for environmentally conscious measures in the construction of the seawall.
[Point here is to have two separate paragraphs lending toward parallel structure with Mike's analysis of the economics. One paragraph is the without project damages which references the former paragraph of environmental inventory (p.9) listing what happens if the seawall fails. The second paragraph is supposed to get at what are the opportunities to prevent those damages (and possibly more) through construction, not just mitigation for the possible damage done through construction. I don't know how to dance around the environmental stuff nearly as well as you do…so you must amend my words. But make the point of the difference in paragraphs for organization and functions sake.]

According to reports provided by the City of Seattle, costs of the alternatives have been estimated to be around $800,000,000 (annualized, $50,000,000, rounded-up, at 5 7/8%, for 50-years). Based on this cursory analysis, estimated average annual damages avoided exceed estimated average annual costs, yielding a positive benefit to cost ratio and indicating that a feasible storm damage reduction alternative does exist.

I. ESTABLISHMENT OF A PLAN FORMULATION RATIONALE.

The conclusions from the preliminary screening form the basis for the next iteration of the planning steps that will be conducted in the feasibility phase. The above-mentioned array of alternatives will be used as a starting point for the next phase of studies. Given the complex nature of this project, and that the recon phase has only preliminarily addressed planning criteria, much work will be done in the first part of the feasibility phase to redevelop sound project purpose, objectives, and constraints. Once the project purpose, objective and constraints are developed, specific measures will be identified that meet the objective requirements and work within the various constraints. Different plans or alternative will be developed through combinations of the various measures. The various alternatives will be screened in terms of their completeness, acceptability, effectiveness, and efficiency by which they meet the planning criteria.

The proposed economic evaluation methodology will be to examine various scenarios and mechanisms that lead to damages in the appropriate National Economic Development (NED) categories with particular attention to damages related to seawall failure and costs of seawall maintenance, to compare to the without project condition. Damages and additional expenses that can be eliminated or reduced under the with-project condition can be claimed as benefits and will thus be used in the project economic analysis. This analysis will be used to determine the recommended plan.

There are at least three scenarios that will expose the waterfront to significant and continual erosive damages. First, the seawall, as it continues to deteriorate, will have an increasing number of minor to moderate structural failures, which will expose the area to tidal and wave erosion. This erosion will undermine existing building, facilities, and utilities causing damages.

The second failure mechanism is moderate to significant damage from a large storm event. With the seawall in its deteriorated and weakened state, it is more susceptible to structural failure from wave action. If this were to occur, the storm would then be able to cause widespread erosion, causing significant damages.

The third scenario is a seismic failure of the seawall. A seismic event of magnitudes common to the region will likely cause catastrophic failure to the seawall, exposing the majority of the area to erosive marine forces causing rapid undermining and structural failure to the study area. This failure, because of its immediacy and impact, contains a high public safety component. Combining these three damage scenarios, with their appropriate time scales and probability, will develop damage over time relationships and/or damage frequency relationships.

In addition to potential failure, the cost of seawall maintenance continues to grow as seawall deterioration continues. This item incurs and will continue to incur significant financial burden over time under without project condition. Particular solutions will decrease the routine damage repairs and maintenance over time thus providing an additional basis for project justification.

Other NED benefits may also be found in the project purposes of recreation and ecosystem restoration. All the potential benefit categories will be investigated and appropriately accounted for in accordance with policy and regulation.

6. FEDERAL INTEREST

Storm damage reduction is a project purpose consistent with established Federal policy and is the primary output of the alternatives to be evaluated in the feasibility phase, there is a strong Federal interest in conducting a feasibility study in partnership with the City of Seattle. There is also a Federal interest in other related outputs of the alternatives including ecosystem restoration and recreation that could be developed within existing policy. Based on the preliminary screening of alternatives, there appears to be potential project alternatives that would be consistent with Army policies, appear to be cost effective and are environmentally acceptable.

The failing seawall and associated damages warrant Corps participation in a feasibility study. As stated above, seawall failure will lead to substantial, rapid, and continual erosion of the study area, undermining and damaging land and facilities. Project benefits would come from the decrease in damages to land and facilities, consistent with established policy. Though the project costs are high, the significant and intensifive development along the Seattle downtown waterfront will likely justify a solution of this magnitude.

7. PRELIMINARY FINANCIAL ANALYSIS

As the local sponsor, City of Seattle will be required to provide 50 percent of the cost of the feasibility phase. The local sponsor is also aware of the cost sharing requirements for potential project implementation. A letter of intent from the local sponsor stating a willingness to purse the feasibility study and to share in its cost, and an understanding of the cost sharing that is required for project construction is included in Appendix A.

8. ASSUMPTIONS AND EXCEPTIONS

A. FEASIBILITY PHASE ASSUMPTIONS

The following critical assumptions and those listed in public concerns will provide a basis for the feasibility study:

(1) Degradation of the seawall will continue over time, accelerating, and leading to continued and more frequent failure.

(2) The worst-case failure would most likely be seismically induced, likely from the earthquake itself or any potential wave energy.

(3) Contaminated materials are expected to exist behind the seawall.

(4) High stakeholder involvement (public, agency, Federal, Tribal)

(5) Project costs are expected to be extremely high.

(6) Imminent failure of the seawall requires a fast paced project development schedule by the City of Seattle, WSDOT and the Corps.

B. STREAMLINING INITIATIVES: The study will be conducted in accordance with the Principles and Guidelines and Corps of Engineers regulations. The local sponsor and

various stakeholders have already performed a great amount of study and analysis into the seawall issue. To the greatest extent practicable and allowable, the Corps will incorporate this work into its analysis. No work performed prior to the signing of a feasibility cost sharing agreement will be creditable towards the local sponsors share of the study, however, this work will likely significantly decrease the amount of work required for feasibility. During the feasibility scoping process, additional items will be identified that will streamline the feasibility study process that will not adversely impact the quality of the feasibility study.

9. FEASIBILITY PHASE MILESTONES

Description	Duration (mo)	Cumulative (mo)
Initiate Study	0	0
Public Workshop/Scoping	2	2
Feasibility Studies	23	25
Alternative Formulation Briefing	5	30
Draft Feasibility Report	3	33
Final Public Meeting	1	34
Feasibility Review Conference	1	35
Final Report to NWD	8	43
DE's Public Notice	1	44
Chief's Report	4	48
Project Authoriztion	6	54

10. FEASIBILITY PHASE COST ESTIMATE

WBS#	Description	Cost
JAA00	Feas - Surveys and Mapping except Real Estate	200,000
JAB00	Feas - Hydrology and Hydraulics Studies/Report (Coastal)	150,000
JAC00	Feas - Geotechnical Studies/Report	200,000
JAE00	Feas - Engineering and Design Analysis Report	500,000
JB000	Feas - Socioeconomic Studies	150,000
JC000	Feas - Real Estate Analysis/Report	500,000
JD000	Feas - Environmental Studies/Report (Except USF&WL)	1,000,000
JE000	Feas - Fish and Wildlife Coordination Act Report	100,000
JF000	Feas - HTRW Studies/Report	200,000
JG000	Feas - Cultural Resources Studies/Report	50,000
JH000	Feas - Cost Estimates	$100,000
JI000	Feas - Public Involvement Documents	1,000,000
JJ000	Feas - Plan Formulation and Evaluation	100,000
JL000	Feas - Final Report Documentation	150,000
JLD00	Feas - Technical Review Documents	100,000
JM000	Feas - Washington Level Report Approval (Review Support)	$50,000
JPA00	Project Management and Budget Documents	500,000
JPB00	Supervision and Administration	100,000
JPC00	Contingencies	800,000
L0000	Project Management Plan (PMP)	25,000
Q0000	PED Cost Sharing Agreement	25,000
Total		$6,000,000

These feasibility cost estimates are based upon only a cursory analysis of the studies to be undertaken. The City of Seattle has already performed extensive analysis, design, and geological sampling that greatly reduces the overall effort required for the feasibility study. A detailed PMP and cost estimate is currently under development.

11. VIEWS OF OTHER RESOURCE AGENCIES

Because of the funding and time constraints of the reconnaissance phase, only limited and informal coordination has been conducted with other resource agencies. Views that have been expressed are as follows:

a. Desires to have project address holistic issues of waterfront development and shoreline usage in project area. With potential work to be done to repair or replace the viaduct, for the Port to move/revamp some of its terminals, and many other plans for development along the waterfront, desire has been expressed that all of these plans, including the seawall, be addressed in a holistic fashion.

b. Any structural fix should be environmentally forward thinkingby providing habitat along the waterfront. In particular, there is an interest in investigating an environmentally beneficial seawallto providing in water habitat function to improve upon the lack of habitat function provided by the existing vertical concrete seawall. [Does this verbage work for you?]

12. POTENTIAL ISSUES AFFECTING INITIATION OF FEASIBILITY PHASE

Continuation of this study into the cost-shared feasibility phase is contingent upon an executed FCSA. Though no issues have yet been identified that may adversely affect the execution of an FCSA, there are significant scoping activities that will occur prior to execution. The schedule for signing the Feasibility Cost Sharing Agreement (FCSA) is January 2004. Based on the schedule of milestones in Paragraph 9, completion of the feasibility report would be in December 2007, with a potential Congressional Authorization in a WRDA 2008.

13. PROJECT AREA MAP

A map and photos of the study area are provided in Appendix B.

14. RECOMMENDATIONS

I recommend that the Alaskan Way seawall study Elliot Bay, Washington proceed into the feasibility phase.

Date _____

Debra M. Lewis
Colonel, Corps of Engineers
Commanding