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THESIS

FORECAST MODELING FOR ESTIMATING BASE REALIGNMENT & CLOSURE (BRAC) ENVIRONMENTAL RESTORATION COSTS

by

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December, 1997

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The U.S. military has faced imposing force structure reductions during the last decade. Complementing the force structure reductions, four rounds of Base Realignment and Closure (BRAC) have been authorized to reduce surplus infrastructure. However, as the BRAC process unfolds, environmental cost issues are being placed under ever increasing scrutiny. Military environmental restoration costs have risen sharply (and above expectations) in recent years, with the unanticipated cost growth occurring most visibly for bases on the BRAC lists.

The complexity of the environmental clean-up enterprise, the numerous and varied regulatory requirements, and the uniqueness of individual installations have led to tremendous difficulty in effective budgeting. In today's austere budgetary environment, a reliable expenditure model is essential to accurately demonstrate the resource requirements necessary to complete suitable environmental restoration and subsequent transfer/reuse of BRAC lands.

To meet the need for an accurate and functional forecast model, thesis research developed and validated a tenable Department of the Navy (DoN) BRAC environmental restoration cost forecast model. The developed model utilized a comprehensive and inclusive multiple regression data analysis to arrive at the most statistically significant set of installation restoration parameters. A spreadsheet-based forecast model implementation procedure, incorporating empirically determined "rules of thumb" for estimating the parametric effects of BRAC initiation, serves as the culminating product of the research effort.

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FORECAST MODELING FOR ESTIMATING BASE REALIGNMENT & CLOSURE (BRAC) ENVIRONMENTAL RESTORATION COSTS

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Submitted in partial fulfillment
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ABSTRACT

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TABLE OF CONTENTS

LIST OF ABBREVIATIONS, ACRONYMS, and SYMBOLS

$CC	Total Cumulative Cleanup Category Cost ($CC=$IA+$RD+$Rmd)
$IA	Total Cumulative Interim Remedial Actions (IRAs) Cost
$IC	Total Cumulative Investigation Cost
$RD	Total Cumulative Remedial Design (RD) Cost
$Rmd	Total Cumulative Remediation Cost
$TC	Total Environmental Restoration Cost ($TC=$IC+$CC)
%Unst	Percent (%) Unsuitable Acreage
ARAR	Applicable and Relevant or Appropriate Requirements
BCA	Base Closure Account
BCTs	Base Closure Teams
BEC	BRAC Environmental Coordinator
BRAC	Base Realignment and Closure
BRAC I	Base Realignment and Closure Round One (1988)
BRAC II	Base Realignment and Closure Round Two (1991)
BRAC III	Base Realignment and Closure Round Three (1993)
BRAC IV	Base Realignment and Closure Round Four (1995)
CA?	Installation Location (State)
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation,& Liability Act
CERFA	Community Environmental Response Facilitation Act
CNO	Chief of Naval Operations
COBRA	Cost of Base Realignment Actions
Coeff	Explanatory Variable Partial Regression Coefficient
CORR Test	Explanatory Variable Correlation Test
DERA	Defense Environmental Restoration Account
DERP	Defense Environmental Restoration Program
DoD	Department of Defense
DoN	Department of the Navy
EA	Environmental Assessment
EBS	Environmental Baseline Survey
EFD	Engineering Field Divisions
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ExcA	Excess Acreage
FFA	Federal Facilities Agreement
FOSL	Findings of Suitability to Lease
FOST	Findings of Suitability to Transfer
FUDS	Formerly Used Defense Sites

FY	Fiscal Year
GAO	General Accounting Office
GPO	Government Printing Office
IAG	Inter-Agency Agreement
InstA	Installation Acreage
IRAs	Interim Remedial Actions
IRP	Installation Restoration Program
LTM	Long-Term Monitoring
MCAS	Marine Corps Air Station
MILCON	Military Construction
NAS	Naval Air Station
NAVFACENGCOM	Naval Facilities Engineering Command
NAWC	Naval Air Warfare Center
NCBC	Naval Construction Battalion Center
NCP	National Oil and Hazardous Substances Contingency Plan
NEPA	National Environmental Policy Act
NPL	National Priorities List
NSTA	Naval Station
NSY	Naval Shipyard
NTC	Naval Training Center
O&M	Operations and Maintenance
OP?	Installation Operational Status
PA	Preliminary Assessment
PPBS	Planning, Programming, and Budgeting System
QDR	Quadrennial Defense Review
RA	Remedial Actions
RABs	Restoration Advisory Boards
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RI/FS	Remedial Investigation / Feasibility Study
RMIS	Restoration Management Information System
RPM	Remedial Project Managers
R-Sq	Coefficient of Determination
R/U	Installation Re-Use Plan Status
S	Standard Error of Estimates
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SI	Site Inspection
SPCC	Spill Prevention, Control, and Countermeasures
Sts(H)	Sites with Relative Risk - High
Sts(M)	Sites with Relative Risk - Medium

Sts(A)-c	Number of IRAs Complete
Sts(A)-u	Number of IRAs Underway
Sts(C)-c	Sites with Cleanup Phase Complete
Sts(C)-u	Sites with Cleanup Phase Underway
Sts(D)-c	Sites with Design Phase Complete
Sts(D)-u	Sites with Design Phase Underway
Sts(RC)	Sites with Response Complete
Sts(S)-c	Sites with Study Phase Complete
Sts(S)-u	Sites with Study Phase Underway
Sts(T)	Total Number of Sites
TSCA	Toxic Substance Control Act
TYPE	Installation Type
UnstA	Unsuitable Acreage
USMC	United States Marine Corps
USN	United States Navy
VAR	Variable
XLOF Test	Experimental Lack of Fit Test
YRCI	Years Restoration Costs Incurred
YTC	Years-to-Completion

I. INTRODUCTION

A. BACKGROUND

The U.S. military has faced unrivaled force structure reductions during the last decade. Spurred by the end of the Cold War and unrelenting "balanced budget" fiscal pressures, military force structure and National Security budget authority have decreased 40% since the pro-military spending days of the mid-1980's [Ref. 1]. Complementing the force structure reductions, though lagging in both extent and duration, four rounds of Base Realignment and Closure (BRAC) have been sanctioned to reduce surplus infrastructure. Reducing and realigning base structure allows the Department of Defense to avert substantial long-term operational costs by eliminating excess capacity.

As the Base Realignment and Closure process unfolds, environmental cost issues are being placed under ever increasing scrutiny by civilian communities, government agencies, and the Congress. The General Accounting Office (GAO) reports that several environmental restoration issues regarding base closure and realignment are in need of resolution. Among the chief concerns are determining accurate cleanup costs, timing appropriations with cleanup needs, and prioritizing available cleanup funds [Ref. 2]. In addition, a purported major cause of installation cost overruns and delayed land transfers is under-forecasted environmental restoration expenditures at BRAC installations [Ref. 3]. The resultant effect of overruns and delays has been the non-materialization of expected budgetary savings from base closure and realignment.

At the heart of the controversy is a long-standing Department of Defense (DoD) policy that excludes environmental restoration costs as a determinant in the base closure decision process. Environmental restoration costs are not included in DoD's net present value analysis. Conventional wisdom contends environmental restoration expenditures are "sunk costs" since public law requires military bases to meet environmental standards regardless of operating status [Ref. 4]. What is absent from this contention is the accelerated timetable and increased rate of resource consumption necessary to meet BRAC time line requirements and reap prompt BRAC savings. In fact, the alternatives DoD foregoes in redirecting limited funding to accelerate environmental restoration have some tangible value (i.e., opportunity cost) that ought to be acknowledged as part of a base closure decision.

B. CURRENT SITUATION

Environmental restoration costs have sky-rocketed in recent years. Additionally, unanticipated cost growth has occurred most visibly for bases that are scheduled to close [Ref. 5]. BRAC annual environmental funding for military departments has grown from $304 million in FY91 to $866 million in FY96 [Ref. 6]. The fundamental complexity and multiple attributes of the environmental cleanup enterprise create significant challenges to effective budgeting [Ref. 7]. Assorted regulatory requirements and the uniqueness of individual installations further complicate restoration efforts and proper budgetary forecasting. In fact, past DoD budget requests have historically understated environmental costs [Ref. 8]. Adding to the predicament, Department of the Navy BRAC facilities are accelerating environmental cleanup actions in order to expedite suitable property transfer or reuse. Without accurate cost forecasting to complement the needed acceleration initiatives, the necessary fiscal resources will not be available to foster prompt property turnover and realize timely savings.

Future base closings and realignments appear likely despite public rhetoric and sensational politicizing to the contrary. The much anticipated and highly regarded Quadrennial Defense Review (QDR) advocates two additional rounds of Base Realignment and Closure (BRACs V & VI). The QDR asserts:

> The downsizing of our infrastructure has fallen behind the downsizing of our force structure, in spite of four BRAC rounds. Since the first base closure round, force structure has come down by 33 percent and will have declined by a total of 36 percent when we finish the reductions under the QDR. During the same period, we have reduced domestic infrastructure by 21 percent as measured by the replacement value of physical facilities. We cannot afford this waste of resources in an environment of tough choices and fiscal constraint. We must shed more weight. [Ref. 9]

Specifically, Defense Secretary Cohen has asked Congress for legislation authorizing the creation of a BRAC for additional base closure rounds in FY99 and FY01. DoD estimates that each round of closures will result in $1.4 Billion in annual recurring savings, after up-front costs are paid [Ref. 10]. It is these inexplicit "up-front costs" that constitute the BRAC environmental restoration program. Due to the up-front cost ambiguity and the perceived excessive environmental expenditures at current BRAC facilities, tremendous attention is expected to be directed toward environmental issues during these upcoming base closure deliberations.

A credible and inclusive environmental cost forecasting model, embodying the beneficial effects of a steep BRAC environmental cleanup learning curve, will promote effective predictions for future costs. In today's austere budgetary environment, a reliable expenditure model is essential to accurately demonstrate the resource requirements necessary to complete suitable environmental restoration and subsequent transfer/reuse of current as well as future BRAC lands.

C. THESIS OBJECTIVES

The thrust of the thesis involves the development of a comprehensive and tenable forecasting model for estimating environmental installation restoration costs at Department of the Navy (DoN) Base Realignment and Closure (BRAC) facilities. The causative forecasting model will be constructed via historical data and will incorporate a set of quantifiable installation parameters.

As a follow-on to the forecasting model formulation, the measurable effects of a BRAC initiation on an installation's key parameters will be ascertained. Initiation of a base closure and realignment action rapidly accelerates a facility's environmental restoration timetable and thus begets a discernible increase in expenditure rate and resource consumption. Applicable parameter "deltas" will be empirically determined from an analysis of historical parameter changes experienced by facilities following the inception of base closure and realignment proceedings. The application of the parameter deltas to current/previous installation parameters will result in revised "expected" installation parameters. The revised parameter values can then be entered into the developed forecasting model to predict costs associated with future initiation of base closure\realignment.

D. RESEARCH QUESTIONS

To properly capture the separate but complementary thesis objectives, two primary thesis research questions are considered:

1. Is there a mathematical combination of quantifiable BRAC environmental restoration cost drivers that will yield an accurate budget forecasting model?
2. To what extent are the key installation parameters sensitive to the initiation of base closure and realignment actions at Department of Navy (DoN) facilities?

In order to fully investigate causal factors necessitating environmental restoration expenditures, the following secondary thesis research questions are considered:

1. What legislative and regulatory programs drive DoN requirements for BRAC environmental restoration?
2. What is the history of DoN BRAC environmental restoration funding?
3. What is the historical variance between actual restoration costs and budgeted restoration costs?
4. What technologies and initiatives result in seemingly reduced environmental costs?

E. THESIS SCOPE

The goal of the thesis is the construction of an adaptable and practical forecasting model to predict environmental restoration costs at Navy installations on, or slated to be on, a base closure list. The causal forecasting model is built on quantifiable installation parameters and includes the predictable parametric consequences expected to be experienced by a DoN facility during the initiation of a BRAC action.

Data analysis is restricted to DoN BRAC installations for the period of FY89 through FY96, inclusive. Recent data (FY94-FY96) having individual anticipated future cumulative restoration expenditures exceeding one million dollars for each fiscal year are featured in model formulation due to the precipitous increase in the quality and quantity of available installation figures and parameters during these years. All data, including the earlier years, are used to discern the effects of base closure/realignment initiation on installation parameters.

The robustness of the forecasting model is tested via calculational cost comparisons of predicted costs (using model) versus actual costs. Testing includes a sampling of non-DoN installation data for FY94-96 to assess envisioned broader model applicability.

F. RESEARCH METHODOLOGY

Thesis research entails two separate data methodologies to address each of the primary research questions. For the mathematical model formulation, the research method is primarily an inductive approach utilizing archival data to determine what measurable installation variables yield the best forecasting results. The strength of archival research lies in the suitability of factual data to statistical analysis and thus, the extrapolation of past trends into the future [Ref. 11].

For determining the effects of base closure and realignment action on installation parameters, the research method is primarily a deductive research approach encompassing a mix of empirical and archival techniques. The intention of this methodology is to quantify an *a priori* hypothesis that assumes installation parameters are meaningfully affected (in the direction of contributing to higher costs) by the initiation of BRAC proceedings.

Research data collection encompasses environmental restoration cost data and a myriad of installation parameters for DoN facilities affected by the first four rounds of BRAC. Compiled data are utilized to build a viable mathematical cost forecasting model. Numerous combinations of data variables and calculational iterations are analyzed to determine the optimal blend of installation parameters, while preserving the simplicity needed for a widely applicable and workable model. The assembled forecasting model is effectively tested via a predicted versus actual cost comparative analysis to determine its estimation ability.

To enhance and direct primary research efforts, a comprehensive environmental restoration program review assesses mission requirements, operating practices, and program funding associated with BRAC. Applicable legislative and regulatory requirements are studied to establish their causal effects as environmental restoration cost drivers.

G. BENEFITS OF STUDY

The definitive result of this research endeavor is a comprehensive and reliable mathematical forecast model to predict environmental restoration costs at BRAC installations. The broad applicability and effective employment of the forecast model yields the following benefits:

1. Reveals critical cost drivers in the environmental restoration process.
2. Assists in effective budgeting for environmental cleanup costs.
3. Assists in the justification of requested funding and proper resource allocation.
4. Quantifies the environmental cost impact on installations due to BRAC initiation.
5. Assists in more accurate estimations of proposed BRAC savings and timetables.

H. ORGANIZATION OF THE STUDY

The balance of the study is presented in the following seven remaining chapters:

- Chapter II provides an overview of DoN's implementation of the Defense Environmental Restoration Program (DERP) vis a vis BRAC. Analysis includes program backgrounds, DERP organization, DERP operations, and applicable legislative and regulatory requirements governing DoD's environmental restoration actions.

- Chapter III presents DoD's Defense Environmental Restoration Account (DERA) and Base Closure Account (BCA) funding histories and status. The chapter concludes with a comprehensive examination of the environmental restoration funding segment allocated and executed by DoN.

- Chapter IV specifies the data collection and management process employed in formulating the mathematical cost forecasting model. The chapter concludes with a description and analysis of the developed multiple regression forecast model.

- Chapter V examines the quantifiable effects of base closure and realignment initiation on installation variables. Installation parameter "rules of thumb" are presented to incorporate parametric effects into the developed forecast model precipitated by the conduct of BRAC proceedings.

- Chapter VI details a spreadsheet-based "user's guide" for implementing the developed environmental restoration cost forecasting model, as well as presenting the outcomes of forecast model validation and broad applicability testing. Comparative analyses involve developed forecast model estimates and DoN planning estimates versus actual costs. Additionally, Army and Air Force installation data are incorporated into the forecast model methodology to test model versatility.

- Chapter VII summarizes the results of the thesis research, highlights the project's major research findings, and presents recommendations for further research and forecast model extension.

II. OVERVIEW OF THE ENVIRONMENTAL RESTORATION PROGRAM

A. INTRODUCTION

This chapter provides an overview of the Defense Environmental Restoration Program (DERP) as it applies to the Base Realignment and Closure (BRAC) process. The chapter describes the Department of the Navy's (DoN) management of the DERP, its operating practices, applicable legislative/regulatory requirements, and program initiatives.

The remainder of the chapter is divided into seven sections. Sections B and C illustrate the backgrounds of both the DERP and BRAC, respectively. Section D outlines DoN's DERP organizational structure. Section E describes DoN's operation of the DERP associated with base closure and realignment. Section F delineates applicable legislative and regulatory requirements driving DERP actions. Section G introduces DERP program initiatives germane to DoN BRAC environmental restoration costs. Section H summarizes the highlights of the chapter.

B. DERP BACKGROUND

The Defense Environmental Restoration Program (DERP) was formally established in 1984 to promote and coordinate efforts for the evaluation and cleanup of contamination at Department of Defense (DoD) installations. The DERP formalized two existing but unstructured DoD environmental programs. The first program was DoD's Installation Restoration Program (IRP), established in 1975 to initiate study and cleanup of contaminated sites in response to the guidance set forth in the National Oil and Hazardous Substances Contingency Plan (NCP). Spurred by the passage of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), the second unnamed existing program intensified the assemblage and evaluation of data pertaining to potentially hazardous activities at DoD installations. Funding in the early years of the DERP consisted of yearly line-item appropriations for FY84 through FY86.

At the outset of the initial DoN cleanup programs, CERCLA and the NCP did not specifically apply to federal facilities. Passage of the Superfund Amendments and Reathorization Act (SARA) in 1986 officially brought all federal facilities under the CERCLA program umbrella. Executive Order 12580 on Superfund Implementation, signed in January of 1987, assigned responsibility to the Secretary of Defense for carrying out the DERP within the overall framework of SARA, CERCLA, NCP, and the EPA's Superfund program. To execute the program, SARA also provided separate funding via a special transfer account, the Defense Environmental Restoration Account (DERA). [Ref. 12]

In May 1993, DoD created the position of Deputy Under Secretary of Defense for Environmental Security to centrally manage the DERP, develop and defend the DERA budget, and allocate funds to all the services. To facilitate effective management of the program, DoN has been delegated both the operational and, most recently, the budgetary responsibility to carry out all DERP functions on property it manages. Additionally, in reaction to escalating concerns regarding environmental restoration issues, the Administration began expressing concern in July 1993 that closing military bases had been cumbersome and slow, with environmental cleanup and other processes taking many years to complete. In response, the Administration announced a five-part program to help accelerate cleanup and community reuse of closing installations. [Ref. 13]

C. BRAC BACKGROUND

Starting in 1988, DoD sought to achieve material savings by closing and realigning military facilities. DoD concluded a reduction in military force structure justified a reduction in military infrastructure. To elevate this troublesome process beyond parochial concerns, Congress established the non-partisan Commission on Base Realignment and Closure (BRAC I). [Ref. 14] The culmination of the Commission's work for BRAC I was the Base Closure and Realignment Act of 1988 (Public Law 100-526), signed October 24, 1988. The law was intended to provide procedures to facilitate the closure and realignment of obsolete or unnecessary military installations. BRAC I actions were to be initiated before January 1, 1990 but no later than September 30, 1991. All closures and realignments were to be complete by September 30, 1995. [Ref. 15]

In similar fashion, for similar reasons, Congress chartered additional commissions to meet in 1991, 1993, and 1995 (BRACs II, III, and IV). Embodying these remaining BRAC rounds in a singular statute (The Defense Base Closure and Realignment Act of 1990 - Public Law 101-510) facilitated the consistent application of commission processes and timetables. Through a comparable legislative review and approval procedure as in BRAC I, the next three commissions required congressional action by September of their respective years before becoming legally binding. The Secretary of Defense then had two years to initiate closure and realignment proceedings and only six years to complete all actions. [Ref. 16]

To avoid potential DoD reluctance in absorbing substantial up-front BRAC costs, Congress created the Defense Base Closure Account (BCA) to provide funding for unique closure and realignment expenditures. It was Congress' intention that separate appropriations earmarked for BRAC would provide for independent financial decisions and avert competition between active and closing installations for coveted Operations and Maintenance (O&M) and Military Construction (MILCON) funds. The majority of BCA funding applies to military construction, relocation, and environmental restoration expenses. Currently, language in the budget assigns a ceiling on the amount of BCA funds allowed to be expended for environmental restoration. DERP funds, however, cannot be used to supplement ceiling shortfalls since all environmental costs associated with BRAC must, by law, come solely from the BCA.

The first four BRAC rounds have directed the closure, realignment, and/or relocation of several hundred active and reserve military installations and support facilities. Included in the process is the closure of nearly 100 major domestic military bases [Ref. 17] and the realignment of over 50 other major facilities. Through the BRAC processes, the Department of the Navy has seen the closure or realignment of over 50 major installations and over 200 minor installations and support facilities [Ref. 18]. Of these actions, the most substantial number of Navy installations was affected via BRAC III of 1993.

It is imperative to understand that environmental restoration efforts for all sites at BRAC installations are also encompassed under the DERP authority. The only material difference between DERP actions at active and closing facilities is the source of funding. Under the BRAC statutes (Public Laws 101-105 and 100-526), sites that would normally qualify for DERA monies are funded out of a separate BRAC account but are still considered part of the DERP. To date, DoD/DoN has managed four rounds of base closure and realignment in this manner.

D. DON DERP ORGANIZATION

As previously cited, the Deputy Under Secretary of Defense (Environmental Security) delegates DERP operational control to each of the services. For DoN, the DERP policy direction and oversight responsibility falls on the Assistant Secretary of the Navy (Installations and Environment). Policy promulgation is further subordinated to the Chief of Naval Operations (CNO) and the Commandant of the Marine Corps. More detailed operational governance is provided by the Naval Facilities Engineering Command (NAVFACENGCOM).

Actual DERP implementation is carried out by the affected Navy and Marine Corps activities with direct management by NAVFACENGCOM Engineering Field Divisions (EFD). There are ten EFDs positioned throughout the United States to provide complete support coverage of DoN facilities. Remedial Project Managers (RPM) from the regional EFD work closely with individual installations, regulators and stakeholders to plan, prioritize, budget, and coordinate DERP execution. The regionally centralized approach provides enhanced partnering capabilities with territorially specific regulators and stakeholders through program consistency, efficiency, economies of scale, and consistent policy. [Ref. 19] Figure 2-1 on the following page depicts DoN's DERP organizational structure.

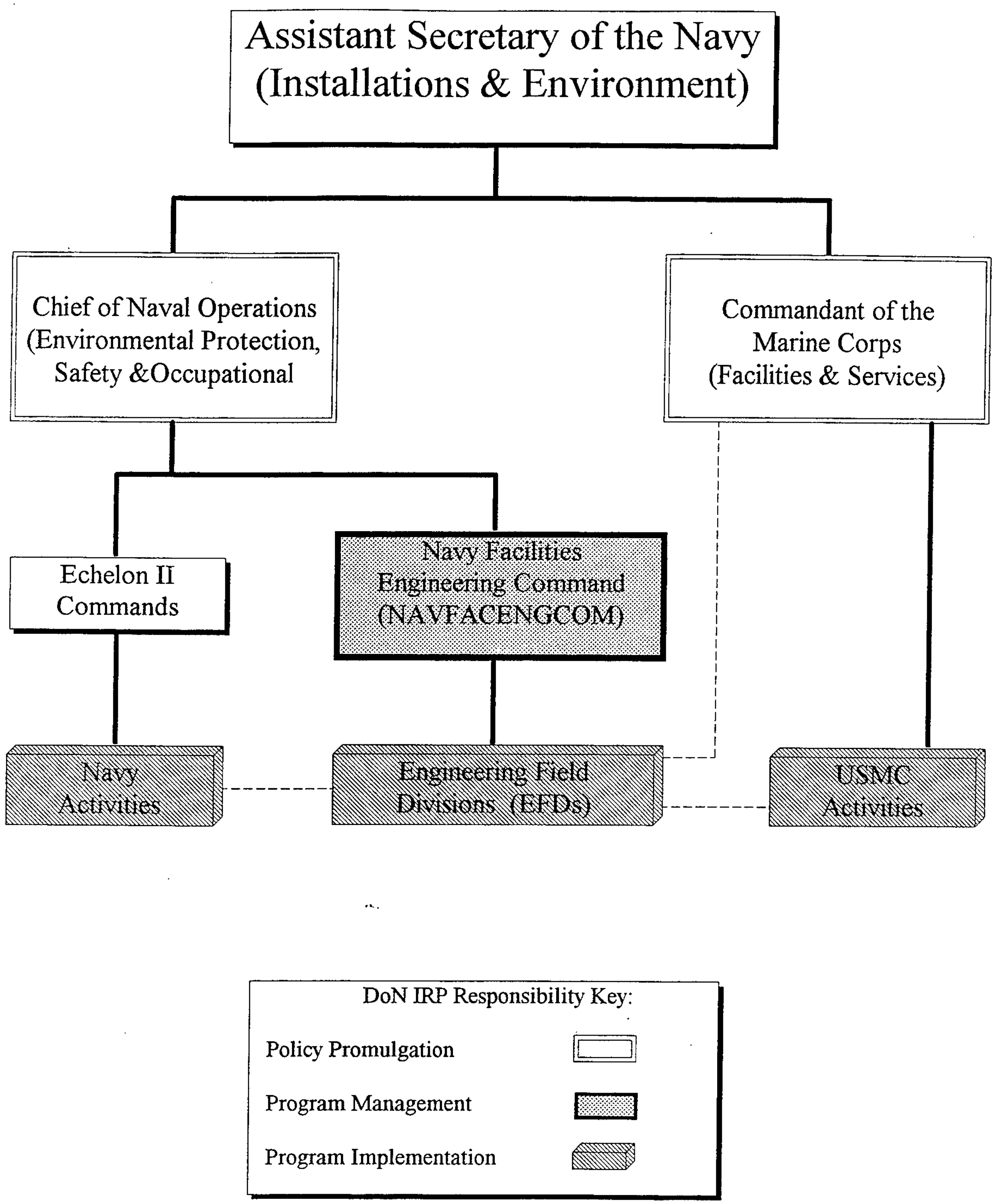


Figure 2-1. The Department of the Navy's IRP Organizational Structure

E. DON DERP OPERATIONS

Today's Navy and Marine Corps facilities occupy roughly four million acres of land in the United States alone. Continued access to these lands, their adjoining coasts, and the airspace above them is a central goal of DoN's environmental program in support of our overall national security strategy. DoN's perspective on DERP is best summarized by statements from the Assistant Secretary of the Navy's (Installations & Environment) office:

> Readiness and protection of the environment are inextricably linked.... Our care for the natural resources entrusted to us by the American people will ensure our continued access to air, water and land necessary to support operational readiness, and the defense of our national interests. It will also ensure that our sailors and marines have environmentally safe living and training conditions. [Ref. 20]

The vast preponderance of the Navy's environmental effort consists of assessing, characterizing, cleaning up, or controlling past contamination in support of CERCLA restoration at active and closing facilities. The Installation Restoration Program (IRP) is the central CERCLA mechanism of DoN's DERP program and historically accounts for an overwhelming majority of all DERP expenditures. The focus of the IRP is to ensure public health and environmental threats are eradicated via the cleanup of contamination associated with past hazardous waste disposal, thus suitably restoring property for future use or reuse.

It is important to restate that IRP directives apply equally to both active and closing installations. In fact, the heightened interest in BRAC restoration issues revealed itself in recent Base Closure Account (BCA) language by specifically directing DoD to ensure that the restorations of any property made excess to the needs of the DoD as a result of BRAC be carried out "as soon as possible with funds available for such purpose." [Ref. 21]

All sites on Navy controlled property within the United States and its territories fall under the domain of the Installation Restoration Program. The IRP consists of a series of phases to identify, characterize, and cleanup hazardous waste. In broad terms, the IRP phases are grouped into two general categories: "Investigation" and "Cleanup." The Investigation category involves Preliminary Assessment (PA), Site Inspection (SI), Remedial Investigation and Feasibility Study (RI/FS). The Cleanup category involves Remedial Design (RD), Remedial Action (RA), and Interim Remedial/Removal Actions (IRA). Although not technically part of IRP cleanup, it should be recognized that environmental Operations and Maintenance (O&M) and Long-Term Monitoring (LTM) are frequently included in the cleanup category for costing purposes. The highlights of each major restoration phase (reviewed in the following subsections) were compiled from the most recent DoN Five-Year Environmental Restoration Plan for Fiscal Years 1997-2001 [Ref. 22].

1. Preliminary Assessment (PA)

The IRP process is nominally initiated with a Preliminary Assessment (PA) conducted by the Naval Facilities Engineering Command (NAVFACENGCOM). The purpose of the PA is to identify potentially contaminated sites at the installation under study. The PA consists of the collection and review of readily available and existing information on past hazardous waste disposal operations or hazardous material spills occurring at the facility. The gathered information is evaluated to determine the potential for hazardous waste contamination. The evaluation considers pathways of exposure, possible receptors, the contamination source, the nature and threat of contaminant release, and the plausibility for removal or treatment.

2. Site Inspection (SI)

A Site Inspection (SI) is performed for all sites identified as potentially contaminated via the PA procedure. The purpose of the SI is to augment PA data collection and generate, if necessary, sampling and other field data to determine if further investigation or action is warranted. The SI consists of an on-site investigation to ascertain the nature and extent of potential or actual contamination release.

Information from the SI and PA are used by the Environmental Protection Agency (EPA) to evaluate an installation's potential inclusion on the National Priorities List (NPL). The NPL is a national list of sites, both public and private, that pose the greatest threat to human health or the environment. Within DoN, a particular site's NPL status applies to the entire installation, unless the EPA and DoN can concur on specific exclusion of certain installation property.

The DoN, in accordance with DoD directives, enters into a Federal Facilities Agreement (FFA) with the cognizant EPA region as soon as possible after NPL initiation. In many instances, affected states are included as participating parties in the FFA. The FFA specifies the roles and responsibilities of the regulatory agencies and DoN, as well as establishing milestones for future cleanup actions.

3. Remedial Investigation / Feasibility Study (RI/FS)

When a site is verified to be contaminated by the SI, the site then advances to a Remedial Investigation / Feasibility Study (RI/FS). The purpose of the RI/FS is to quantify the nature and extent of the threat posed by the contamination and, when appropriate, evaluate proposed remedies. The RI portion of this phase is a detailed study involving a variety of investigative sampling and analytical procedures. RI includes the collection of soil, air, water, and other samples necessary to determine contaminant characteristics, hazards, and exposure routes.

The Feasibility Study (FS) portion uses generated RI data to identify potential cleanup actions. During the FS, a number of remedial alternatives are conceived and screened to evaluate their ability to meet a range of remediation factors, including technical and regulatory requirements. After consideration of public and regulatory agency comments, the RI/FS is concluded by the selection of a remedy method or a recommendation for no further action. Completion of the RI/FS phase marks the end of the IRP Investigation category.

4. Remedial Design (RD)

Once a site is identified in the RI/FS as requiring cleanup action, the site moves into the Remedial Design (RD) phase. The purpose of the RD phase is to prepare all technical documentation and specifications fundamental to the successful implementation of the agreed upon contaminant cleanup action. The initiation of RD phase operations marks the beginning of the IRP Cleanup category.

5. Interim Remedial Actions (IRAs) and Removals

Interim Remedial Actions (IRAs) and Removals may be undertaken at any point during the investigation or cleanup of a site. The flexibility of these actions is intended to allow rapid response to contaminant release that presents an imminent or substantial threat to human health or the environment. IRAs also serve to quickly reduce overall site risk and to stabilize a site until final cleanup action can be accomplished. On an increasing basis, DoN is utilizing IRAs as a tool to expeditiously react to site contamination, reduce investigation costs, and accelerate the cleanup process.

6. Remedial Actions (RA)

Remedial Action (RA) is the actual construction, operation, and implementation of the designated final cleanup action. In many instances, the final remediation action may include long-term operations and monitoring of treatment systems that extend well into the future. In these cases, the RA phase is considered complete when the selected remedy is in place and is functioning as intended.

The question of "how clean is clean?" is a widely contested issue among all participants in the environmental restoration business. The argument stems from deviating opinions on how much remediation is required to clean contaminated parcels. The answer depends largely on who sets the remediation standards and what criteria are used to measure success. Per the Community Environmental Response Facilitation Act of 1992 (CERFA), the ultimate remediation arbiter is the EPA or the state environmental regulators. Their decision basis, however, can be negotiated and thus may be different for each parcel.

The cleanup level decision is much easier for bases not facing closure. Active installation cleanup is done to satisfy current use standards based on the types of operations conducted in that area. For closing bases the cleanup issue is far more complicated. CERFA, contrary to historical practices of transferring federal property "as is", requires the government to retain responsibility for all remediation actions. Secondly, it is recurrently unclear whether closing bases should be cleaned to current use standards, planned reuse standards, or restored to original property condition. These difficulties encountered in the cleanup of BRAC parcels can lead to lengthy remediation delays, elaborate reuse arrangements, and expensive remediation rework.

F. LEGISLATIVE AND REGULATORY REQUIREMENTS

In the past, military and civilian industries were not particularly conscientious about hazardous contaminant use and disposal. As public rhetoric and citizen education on the dangers of environmental contamination intensified, so too did the amount and extent of regulatory mandates. These numerous and varied laws and regulations are the engine that drives environmental control and restoration endeavors.

Environmental programs attempt to convert all applicable statutes and regulatory requirements into a workable process. In fact, as was previously described, DoN's entire environmental restoration program was conceived and launched as a response to two major legislative actions - the Comprehensive Environmental Response, Compensation and Liability Act of 1980; and the National Oil and Hazardous Substances Contingency Plan. The present form of the Navy's IRP strives to encompass all prescribed edicts spelled out in numerous legislative and regulatory requirements. Since mandated requirements drive IRP structure and operations, they are also chiefly responsible for program costs. In fact, DoD has stated to Congress that legislation and regulations have "served as the basis for most policies and decisions that affect priorities and funding of the program." [Ref. 23] The subsections below summarize pertinent laws and regulations weighing significantly on DoN's environmental restoration enterprise. Information contained in the subsections was abstracted from DoN's Five-Year Environmental Restoration Plan for Fiscal Years 1997-2001 [Ref. 24].

1. CERCLA

The Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), commonly referred to as the Superfund Act, gave federal agencies authority to respond to the release or substantial threat of release of hazardous substances into the environment. CERCLA also extends its authority to situations where contaminants and pollutants present imminent and substantial danger to public health. Additionally, CERCLA (and its follow-on amendments) requires that other federal laws and more stringent state regulations be considered when conducting response actions. Examples of such laws that may be considered as Applicable and Relevant or Appropriate Requirements (ARARs) include: the Resource Conservation and Recovery Act (RCRA); the Toxic Substance Control Act (TSCA); the Clean Air Act (CAA); and the Safe Drinking Water Act (SDWA).

2. NCP

The National Oil and Hazardous Substances Contingency Plan (NCP) is the base regulation that implements the statutory requirements of CERCLA and the Clean Water Act. The NCP provides organizational structure and operational procedures in preparing for and responding to discharges of oil and the release of hazardous substances, pollutants, and contaminants. The NCP also establishes initial response action and notification procedures for the release of a reportable quantity of hazardous substances. The NCP was the impetus behind the formation of the IRP. DoD/DoN must comply with the NCP regulation as law.

3. NEPA

The National Environmental Policy Act of 1970 (NEPA) requires federal agencies to consider environmental impacts of proposed "major actions." The law defines a specific decision-making process that must be followed to determine such impacts. Until an agency completes its NEPA review, work on a proposal cannot be initiated. Major actions having a significant effect on the environment require an Environmental Impact Statement (EIS). Major actions for which environmental impact is not known or is insignificant require an Environmental Assessment (EA). Federal Register notices are required for any EIS and EA. Federal agency decisions under NEPA are subject to review by the courts.

Conventionally, BRAC proceedings are considered major actions and are thus subject to NEPA. Additionally, when IRP operations follow the NCP and fulfill public participation requirements, then the IRP is deemed to have complied with NEPA. To help clarify early misconceptions with the NEPA-BRAC linkage, the Base Closure and Realignment Act of 1990 included specific language to address the NEPA issue. In general, the 1990 BRAC act stated that NEPA does not apply to the closure *decision* but does apply to the property disposal process and the relocation of functions from closed or realigned facilities. [Ref. 25]

4. SARA

The Superfund Amendments and Reauthorization Act of 1986 (SARA) reauthorized CERCLA funding and amended the authorities and requirements of CERCLA and other associated laws. Congress extended the authorization of CERCLA since the program's authority was lapsing and its charter was far from complete.

SARA is divided into five major titles. Titles I and III are most directly related to the DERP and the IRP. Title I, section 120, established special funding (DERA) to pay for the cost of DoD responses to hazardous waste sites. Title III established the Environmental Planning and Community Right to Know Act of 1986. Although Title III does not directly apply to federal agencies, it is DoD's policy to comply with its provisions to the maximum extent practicable. Under Title III, facilities are required to train personnel in hazardous spill response, notify local emergency response planners of hazardous substances on the property, and upgrade their Spill Prevention, Control, and Countermeasures (SPCC) plans.

5. CERFA

The Community Environmental Response Facilitation Act of 1992 (CERFA) amends CERCLA and requires the Federal Government to identify real property on each facility which is not contaminated. This process, commonly referred to as "parcelization", is intended to identify land that offers the greatest opportunity for expedited reuse and redevelopment by the community. The identified parcels of real property must be either free from hazardous substances and petroleum products or the remediation of contamination must be expedited to facilitate transfer to the public.

The CERFA law states that federal findings must be concurred with by the EPA (for an NPL site) or the appropriate state officials (for non-NPL sites). Concurrence of real property applies equally to BRAC and non-BRAC facilities. An additional stipulation commands BRAC facilities to both identify parcels and receive concurrence reports within 18 months after being designated a BRAC installation.

The Environmental Baseline Survey (EBS) is the DoD process utilized to evaluate and identify a parcel's environmental condition. The EBS process has been standardized among the services via DoD guidance and defines seven "Area Types" for categorizing of property. The EBS also serves as the conclusive property status document required for government real estate transactions under the Findings of Suitability to Lease (FOSL) and Findings of Suitability to Transfer (FOST) programs.

When the property is transferred, the federal government retains responsibility for any remediation or response action found to be necessary after the date of transfer. Long-term monitoring and environmental operations and maintenance will not prevent the transfer of federal property, as long as planned remedial action is complete, or installation of approved remedial design is complete and proper remedy operations have been demonstrated.

G. DERP INITIATIVES

Program initiatives are the responses commissioned to achieve compliance with the environmental laws and regulations in an ever-changing climate. As a consequence, program initiatives drive DERP composition and operations and are thus directly attributable to program expenditures. DoD continually takes measures to optimize the quality, speed and cost of environmental restoration. Practices are changed in order to reduce environmental risk, achieve faster cleanups, and realize optimal restoration progress with a decreasing public tax dollar funding base. In increasing fashion, the initiatives have been planned and conducted in close concert with federal, state and local regulators, as well as stakeholders, communities, and private industry.

The most sweeping recent initiatives were born out of the Administration's 1993 five part Community Reinvestment Program striving to accelerate the economic revitalization of communities affected by BRAC actions. Fast Track Cleanup, one of the five major initiatives of the President's plan, has proven to be a leading force in DoD environmental restoration endeavors. DoD has developed several Fast Track implementation guidance instructions over the past few years in cooperation with the EPA and several state regulators. Key Fast Track issues pertinent to DoN restoration efforts are outlined below. Descriptions are summarized from statements by the Deputy Under Secretary of Defense (Environmental Security) presented before the Senate Appropriations Committee, Subcommittee on Defense, in hearings addressing Environmental Security Programs [Ref. 26].

- BRAC Cleanup Teams (BCTs): Teams consisting of DoD, EPA, and state environmental professionals are created at each major closing base to cooperatively develop and review all cleanup plans. BCTs seek to accelerate remedial efforts needed to prepare real property for transfer and reuse.

- Parcelization: Under CERFA authority, DoD makes available clean parcels of land for immediate transfer to local communities while other contaminated parcels continue to be remediated. To expedite the availability of parcels requiring minimal cleanup actions, DoD and the EPA have partnered to develop model lease language.

- NEPA Reviews and Re-Use: To facilitate rapid property transfer, NEPA documents are to be completed within 12 months after community submission of its final Re-use plan. The Re-use plan serves as the "major action" addressed in the NEPA analysis. The subsequent NEPA findings, in turn, fulfill statutory requirements for both closure and re-use actions.

- Indemnification: DoD, as provided by law, ensures future property users at closing bases are indemnified from liability for past contamination. The initiative's intent is to speed property transfer by eliminating stakeholders' future liability anxieties.

- Restoration Advisory Boards (RABs): RABs consist of DoD, EPA, and local regulatory officials reflecting diverse interests at all major closing bases. RABs serve as a forum for public comment and exchange of restoration information, as well as give stakeholders the opportunity to participate in the cleanup process. Underscoring RAB program importance, recent Defense Authorization Acts require annual reporting on the activities of, and funding for, each installation's RAB [Ref. 27].

Aside from the Fast Track Program, other notable initiatives significantly affect DERP operations. Two of the more pivotal undertakings are the Relative Risk Reduction Program and the devolvement of program funding. The Relative Risk Reduction Program initiative classifies installation sites into several categories (high, medium, low, not evaluated, not required) to prioritize and sequence work, produce quantifiable performance measures, and provide a basis for justifying requirements and funding.

The initiative to devolve DoD's DERA to each of the services in FY97 developed out of growing program size and the maturing nature of the services' partnering efforts with the regulatory communities. Devolvement seeks to improve planning, budgeting, accountability, and oversight by forcing the consideration of environmental restoration demands with other mission requirements during the planning, programming, and budgeting (PPBS) cycle. Under devolvement, however, the Base Closure Account (BCA) remains as currently structured.

It is imperative to mention that most program initiatives encompass restoration efforts at BRAC facilities, especially the profound emphasis on cleanup/remediation actions while maintaining only necessary investigation work. In addition, both technology implementation and research and development play an expanding role in the DERP/BRAC execution and costing. Several technological ventures greatly influence restoration operations through active technology transfer and innovative cleanup designs. Unfortunately, uncompromising budgetary constraints and hurried timeline restrictions provide constant challenges and hamper progress in the technology area. The broad subjects of restoration technology and research and development provide ample opportunities for meaningful examination, yet these topics fall beyond the scope of research intended for this thesis.

H. SUMMARY

Chapter II provides a chronological perspective and the operational framework of the Defense Environmental Restoration Program (DERP) vis a vis Base Realignment and Closure (BRAC). The DERP and BRAC background reviews establish each program's administrative scheme and the historical influences that configure their functionality.

The description of current DoN DERP organizational and operational systems provides the fundamental framework crucial to suitably analyzing program oversight, implementation, and execution. Of specific importance is acknowledging the functional differences among the categories and phases associated with environmental restoration efforts. Each category and phase has certain requirements and procedures that uniquely steer its activities, and ultimately, its expenditures and expenditure rate. In general, the phases of

Investigation cover vast amounts of real estate, require substantial time to complete, and serve as a base for follow-on actions. The Cleanup phases are characterized by concentrated and high cost end-product activities. Recent trends have suggested that time consuming and sequential Investigation activities can be reduced in favor of accelerated Cleanup actions.

The applicable legislative and regulatory requirements governing the DERP and BRAC processes unequivocally underpin program formation and initiatives. The most notable regulatory mandates include the National Environmental Policy Act of 1970 (NEPA), the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), the Superfund Amendments and Reauthorization Act of 1986 (SARA), and the Community Environmental Response Facilitation Act of 1992 (CERFA). CERCLA (and SARA) formed the basis for the DERP IRP process and their mandates created much of the existing structure. NEPA requirements drive many of the program operations and initiatives to satisfy its evaluation and reporting commitments. CERFA, in mandating DoD's parcelization efforts, is the most recent major legislation affecting BRAC.

Program initiatives are generally the result of legislative and regulatory compliance in a dynamic political and budgetary situation. Examining DERP initiatives reveal trends in program composition and operation, ultimately unveiling the environmental restoration cost drivers. Notwithstanding the sweeping drive to accelerate remediation actions over investigation actions, several initiatives dominate the program. The Fast Track Cleanup initiative comprises the vast majority of BRAC environmental restoration undertakings. Additionally, the recent Relative Risk Reduction Program initiative provides a framework for prioritizing work, measuring performance, and justifying requirements and funding.

III. ENVIRONMENTAL RESTORATION PROGRAM FUNDING

A. INTRODUCTION

The Department of Defense (DoD) financed nearly $15 billion through FY96 in environmental restoration activities through the Defense Environmental Restoration Program (DERP). The budget history of the DERP demonstrates a growing preoccupation with environmental and public health concerns. For example, DoD funded just $150 million in FY84 for environmental restoration efforts at military facilities. In contrast, DoD spent nearly ten times that figure ($1.4 billion) in FY96, with a peak yearly expenditure of almost $2 billion in FY94.

Through FY96, Congress provided funds for DoD environmental restoration in two distinct accounts: approximately $11.4 billion in the Defense Environmental Restoration Account (DERA) for operational facilities and approximately $3.5 billion in the Base Closure Account (BCA) for BRAC installations [Ref. 28]. Commencing in FY97, the DERA monies are granted in five separate service accounts in accordance with the program's devolvement initiative. The BCA, however, continues to be executed in its customary fashion.

It is not uncommon, nor inconsistent, to see environmental restoration expenditure totals expressed in the combined terms of the DERA and the BCA. In fact, all of the DoN BRAC installations utilized in the detailed analysis portion of this thesis expended DERA funds prior to being placed on their respective BRAC lists. Consequently, the cumulative year-to-date expenditure totals employed in model formulation and evaluation consist of both DERA and BCA funds. It is important to recognize that once a facility has initiated BRAC proceedings, it is then required by law to only allocate BCA environmental funds for subsequent restoration efforts. Figure 3-1 below illustrates DoD's environmental funding history from FY84-FY96.

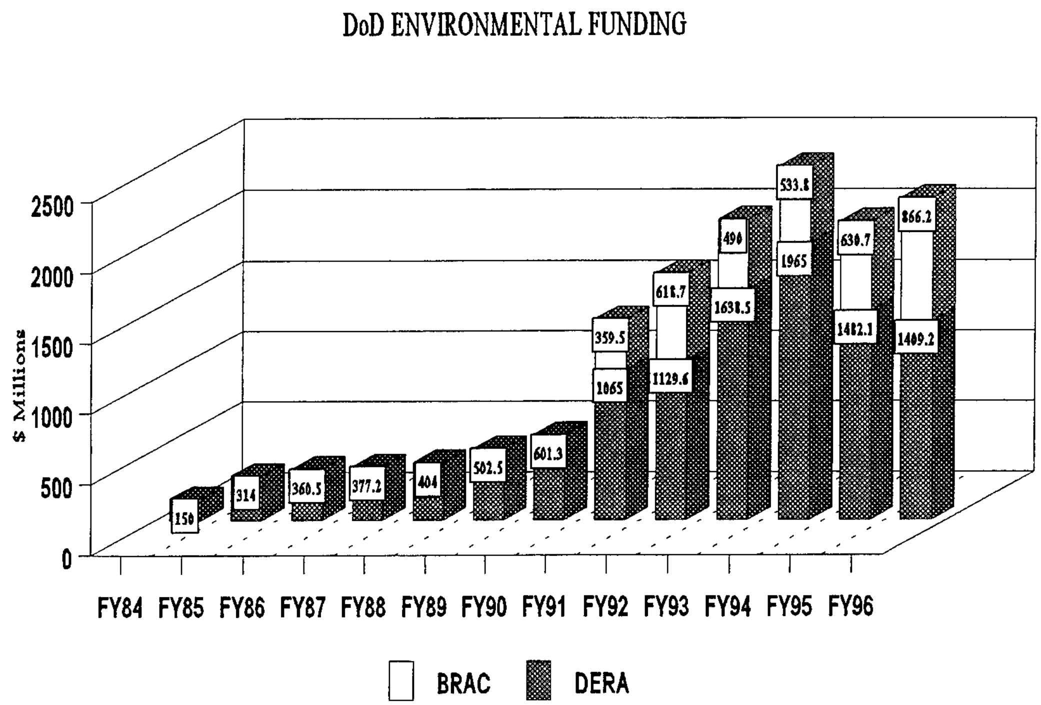


Figure 3-1. DoD Environmental Restoration Funding History (FY84-FY96)

The remainder of the chapter is divided into four sections. Section B presents DoD's DERA funding history and status. Section C presents DoD's BRAC environmental funding history and status. Section D illustrates DoN's environmental restoration funding situation. Section E summarizes the highlights of the chapter.

B. DOD DERA FUNDING

The Department of Defense has dramatically expanded its environmental restoration operations and funding in the 1990's to combat rapid growth in the number of identified contaminated sites, escalating regulatory requirements, and the general movement of the program into the more complex and costly remediation stages. Figure 3-2 below underscores both the accelerated growth of the DERA, as well as, the realities of inconsistent funding.

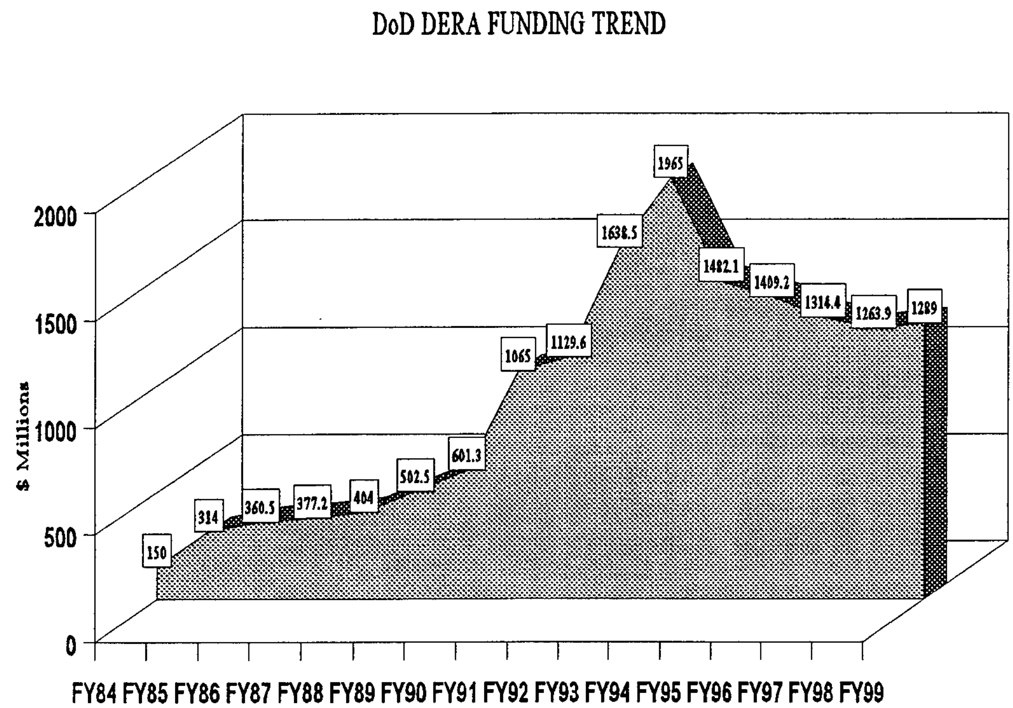


Figure 3-2. DoD DERA Funding Trend (FY84-FY99)

Although required to satisfy escalating requirements, the steep funding slope between FY90 and FY94 was not easily managed. The steep funding curve merged with a coincidingly steep restoration learning curve to present difficult challenges in the planning, programming, budgeting, and execution of the program. In FY95, when the program had achieved critical momentum and execution capabilities were in line with funding levels, DERA funding was significantly reduced below that needed to fund planned restoration activities. [Ref. 29]

The undulating nature of the DERA demonstrates the consequences of inconsistent yearly appropriations. Maturing programs such as the DERP are best served by stable funding commensurate with forecasted operations. In this regard, stable funding does not necessarily connote level funding but, rather it connotes manageable change consistent with future planned expenditures. Manageable funding variations are especially critical to the multi-year nature of environmental restoration operations since there is a direct correlation between appropriations and execution in one year and continuing restoration progress in subsequent years. [Ref. 30]

The configuration and amounts of Figure 3-3 on the following page highlight the "cleanup versus investigation" initiative influencing environmental restoration at both active and closing installations. As portrayed in the figure, cleanup costs are increasing while investigation and management costs are decreasing appreciably. DoD's approach is aimed at maintaining the momentum gained in recent years and establishing program remediation stability in the face of funding reductions. The program attempts to complete operations in accordance with statutory requirements by prioritizing cleanup and investigation work on a relative risk reduction basis. [Ref. 31]

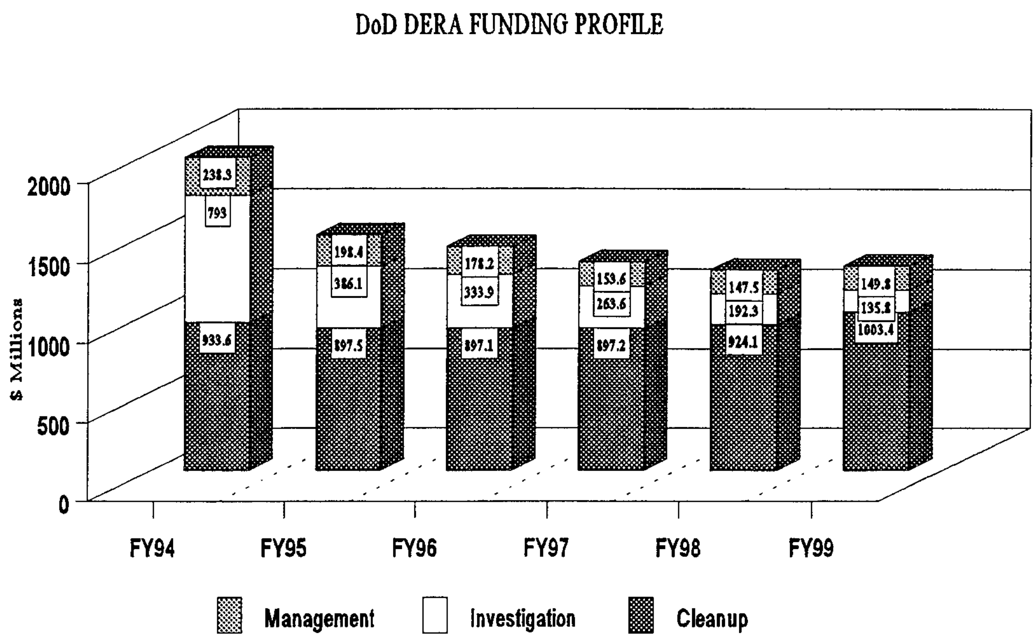


Figure 3-3. DoD DERA Funding Profile (FY94-FY99)

The categories portrayed in Figure 3-3 above correspond to those described in Chapter II. As a means of summarization, Figure 3-3 categories are recounted below. The Cleanup category includes: Interim Remedial Actions (IRAs) and Removals; Remedial Action (RA); Remedial Design (RD); environmental Operations and Maintenance (O&M); and Long-Term Monitoring (LTM). The Investigation category includes: Preliminary Assessment (PA), Site Inspection (SI), and Remedial Investigation/Feasibility Study (RI/FS). The Management category includes: program administration costs such as travel, training, and support costs, as well as the reimbursement of outside entities for technical services.

C. DOD BRAC ENVIRONMENTAL FUNDING

Funding for DoD's BRAC environmental program is part of the overall Base Closure Account (BCA) which supplies six subaccounts, including one for the BRAC environmental restoration effort. DoD annually presents Congress with a detailed budget submission to justify requested BCA funds. The submitted budget is utilized by Congress to make separate appropriations for each BRAC round.

To provide optimal control, BRAC appropriations are provided in five year accounts and thus need not be obligated in the year of appropriation. Additionally, with the exception of the environmental subaccount prior to FY96, BCA monies need not be used in the subaccount for which they were requested. Prior to FY96, legislation established a floor for the environmental subaccount requiring DoD to spend no less than the appropriated amount. Consequently, the minimum environmental subaccount amount could not be reallocated to other subaccounts. However, starting in FY96 the Defense Appropriations Act established an environmental subaccount ceiling above which DoD is prohibited from spending unless it notifies Congress. The ceiling provision now allows environmental funds to be shifted among all subaccounts. [Ref. 32]

The BRAC environmental subaccount funding profile shown in Figure 3-4 on the following page reflects BCA funding allocations, by BRAC round, for FY91 through FY96 and budgeted funding for FY97 through FY99. In addition to notional BRAC environmental restoration costs, the BCA environmental subaccount provides funds for closure-related environmental compliance and environmental planning. As is the case with DERA funds, BCA environmental appropriations are executed by NAVFACENGCOM under the DERP.

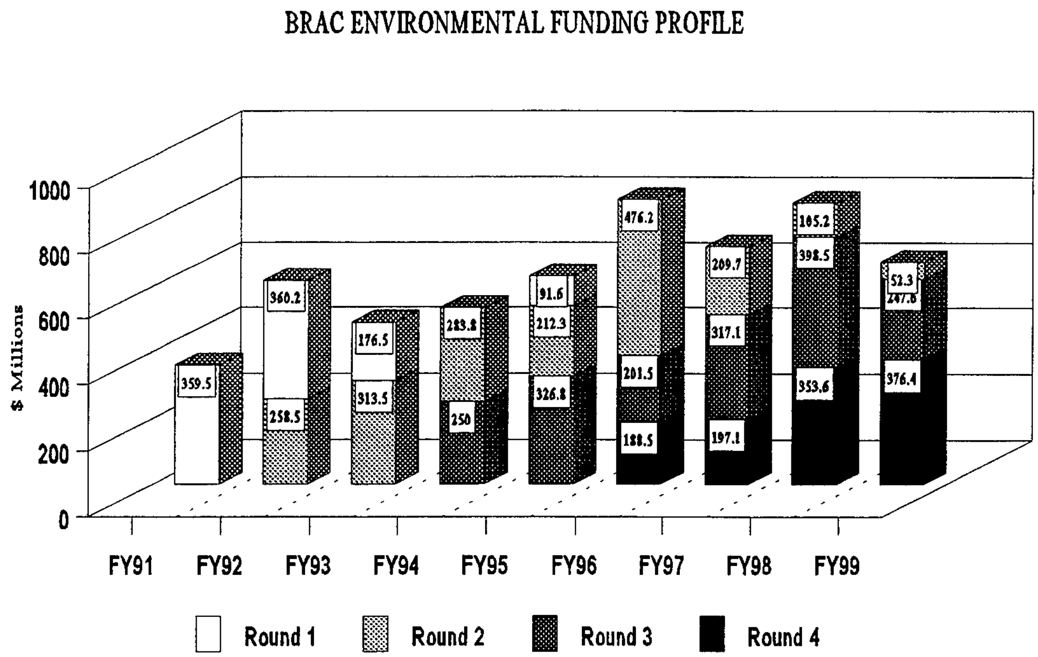


Figure 3-4. DoD BRAC Environmental Funding Profile (FY91-FY99)

D. DON ENVIRONMENTAL FUNDING

Since 1984, roughly $2.5 billion in DERA funding was spent identifying, assessing, and cleaning up past hazardous waste disposal sites at Navy and Marine Corps installations. During the early years, DoN spent an ample amount of this DERA funding on investigations to locate sites and characterize the nature and extent of contamination. The increased emphasis on cleanup actions has resulted in a significant shift in resource allocation in the past several years. For example, DoN spent only 14% of its DERA portion on cleanup in FY92. In FY96, the cleanup category of the DERP accounted for 64% of DoN's DERA funds. To incentivize further cleanup progress, the FY96 Defense Authorization Act established a goal requiring 80% of program funding to be used for actual cleanup beginning in FY98. [Ref. 33]

BRAC funds, in the form of the BCA environmental subaccount, have been executed by DoN to fulfill restoration requirements for the 1,035 total DoN BRAC sites as of the end of FY96. Cleanup progress at the DoN sites has increased nearly six-fold since FY94. DoN's share of DoD's BRAC environmental subaccount, both in actual dollar amounts and as a percentage of the subaccount total, is shown in Figure 3-5 below.

The inter-year fluctuations highlight the focus of the BRAC restoration program on achieving prescribed remediation timelines. For instance, the abrupt decline in Navy funding percentage in FY96 can be attributed to the abrupt increase in Army funding largely due to the looming finish to the BRAC I closure timeline in which the Army was most severely impacted. In contrast, the forecasted DoN funding percentages for FY97 and beyond are notably increased to address the timeline restrictions for BRAC III in which the Navy was most severely impacted.

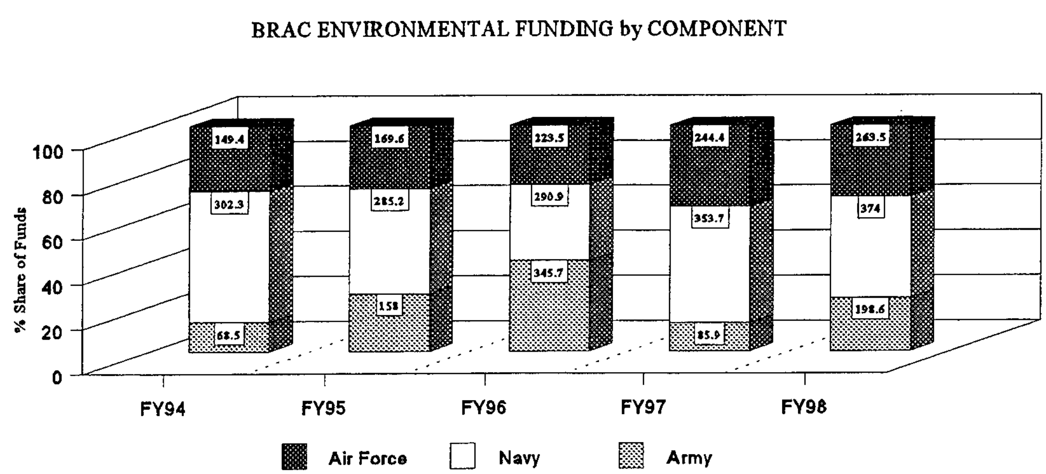


Figure 3-5. DoD BRAC Environmental Funding by Component

E. SUMMARY

The funding legacy of the Department of Defense's (DoD) Defense Environmental Restoration Program (DERP) provides unequivocal evidence of the expanding importance our nation places on environmental safety and public health. To fund DoD's environmental restoration efforts in this regard, Congress provides funds in two separate accounts: The Defense Environmental Restoration Account (DERA); and the environmental subaccount of the Base Closure Account (BCA). The DERA primarily incorporates operating installations while the BCA subaccount incorporates closing and realigning installations. Although their utilization is strictly segregated by statute, the two accounts are organizationally linked. In fact, all of the DoN BRAC installations utilized in the forecasting model formulation of this thesis consumed DERA funds prior to being placed on their respective BRAC lists.

In terms of both active and closing installations, DoD has experienced a marked expansion in its environmental enterprise this decade to confront rapid contaminated site growth, elaborate regulatory mandates, and increased remediation tasks. In addition, DoD's emphasis on cleanup activities has resulted in a pronounced rise in both the number of true remediation actions and the expenditures associated with this more elaborate endeavor. The cleanup initiative seeks to conclude restoration in accordance with statutory requirements via a site relative risk reduction prioritization of cleanup and investigation operations.

The BCA furnishes the greatest flexibility in meeting unique and stringent regulatory and requirements timeline restrictions for BRAC facilities. Funding for DoD's BRAC environmental restoration comes from one of six BCA subaccounts appropriated by Congress. The BCA environmental subaccount is executed by NAVFACENGCOM under the DERP in similar fashion to DERA appropriations. The BCA funds are provided in flexible five year accounts and the subaccounts are not fenced. There is, however, a statutory ceiling for the BCA's environmental subaccount to limit expenditures for restoration.

In the last 12 years, nearly $4 billion in environmental restoration funding (DERA and BCA) was spent identifying, assessing, and cleaning up past hazardous waste disposal sites at both active and BRAC Navy and Marine Corps installations. A significant segment of the early DoN DERA funding, especially in the investigation category, was expensed on sites at installations subsequently affected by the four rounds of BRAC. The BRAC funds, in the form of the BCA environmental subaccount, have been expended by DoN to exclusively fulfill the environmental requirements for the 1,035 sites on Navy controlled property. The bulk of recent DoN BCA environmental funds has supported the cleanup category of the restoration program, increasing expenditures in cleanup phases by roughly six times in the last few years. DoN's ability to concentrate BRAC environmental monies on genuine remediation is due in large part to both DoD's "cleanup versus investigation" initiative and the previous expenditures of DERA funds on the site investigation phases.

IV. DATA DESCRIPTION AND FORECAST MODEL FORMULATION

A. INTRODUCTION

The primary thesis objective is the development of a comprehensive and serviceable forecasting model for estimating environmental restoration costs at Department of the Navy (DoN) Base Realignment and Closure (BRAC) facilities. The model detailed in this chapter is constructed via historical data, incorporating a set of quantitative and qualitative installation parameters to determine significant restoration cost drivers and estimate future expenditures.

The remainder of the chapter is divided into five sections. Section B describes the collection and employment of the installation restoration data utilized in model formulation. Section C introduces the regression analysis, presenting the essential basics of causative model forecasting needed to interpret and analyze regression results. Section D explains the adopted regression model methodology. Section E presents a review and interpretation of the generated forecasting model outcomes. Section F summarizes the chapter highlights.

B. DATA COLLECTION AND DESCRIPTION

Research data collection encompassed environmental restoration cost data and a myriad of installation parameters for DoN BRAC facilities for the period of FY89 through FY96. The compiled data were configured to build the most viable mathematical cost forecasting model given the available data. Recent data for FY94 through FY96 proved to be the most valuable in model formulation due to the precipitous increase in the quality and quantity of available installation information during these years. The facilities employed in model formulation were further pared to major DoN BRAC facilities having anticipated future cumulative restoration expenditures exceeding one million dollars in each year (FY94-FY96) being studied. The fiscal restriction is necessary due to the limited amount of comprehensive data available once an installation falls below the million dollar future expenditure threshold. In addition, the later timing of BRAC IV precluded those facilities from model inclusion. However, the BRAC IV facilities were used to test model validity as illustrated in Chapter VI.

For purposes of forecast model development, a total of 17 DoN facilities met all the selective data conditions. Extensive parametric data were compiled for each of the 17 facilities over the FY94-FY96 period, yielding a total of 51 autonomous data points. Each installation data point entails multiple explanatory variables with which to build the regression model. The installations employed in model formulation are listed in Table 4-1 below.

INSTALLATION	**INSTALLATION**
Agana Naval Air Station	Mare Island Naval Shipyard
Alameda Naval Air Station	Moffett Field Naval Air Station
Barbers Point Naval Air Station	Orlando Naval Training Center
Cecil Field Naval Air Station	San Diego Naval Training Center
Davisville Naval Construction Battalion Center	Treasure Island Naval Station
El Toro Marine Corps Air Station	Trenton Naval Air Warfare Center
Glenview Naval Air Station	Tustin Marine Corps Air Station
Hunters Point Annex Naval Station	Warminster Naval Air Warfare Center
Long Beach Naval Station	

Table 4-1. DoN BRAC Installations Employed in Regression Model Formulation

After establishing the viable installations to be utilized in forecast model formulation, an exhaustive collection of dependent and explanatory variable candidates was compiled. The choice of the dependent variable candidates was self-evident given the central thesis focus of forecasting environmental restoration expenditures. The dependent candidates quite naturally included the available installation restoration cost data. Data for the dependent variables were derived primarily from the DERP's Annual Reports to Congress for FY94 through FY96 and installation information provided by NAVFACENGCOM via their Site Base Cleanup Plan internet web pages [Ref. 34]. Specifically, each dependent variable shown in Table 4-2 below was applied in numerous regression analyses to determine the most functional choice.

Symbol	**Dependent Variables**
$IC	Total Cumulative Investigation Category Cost
$CC	Total Cumulative Cleanup Category Cost
$TC	Total Cumulative Restoration Cost ("Investigation" plus "Cleanup")

Table 4-2. Dependent Restoration Cost Variables

The collection of explanatory variable candidates is expectedly much more extensive than that of the dependent candidates. Inasmuch as the selection of the dependent regression variable is readily apparent, the selection of explanatory variables - especially in empirical research - is far less evident. The explanatory variables amassed for model formulation included 25 individual parameters for each installation. These variables are categorized in two broad divisions - quantitative and qualitative - based on their data properties.

Quantitative variables are the most familiar parameter type, consisting simply of data available in a quantitative cardinal number format. In contrast, qualitative variables account for relevant categorical data qualities not conventionally measured on a numerical scale. To construct a factual and meaningful estimating model, the regression analysis must account for the influential qualitative explanatory variables that cannot be readily quantified. In regression modeling, the categorical (or "dummy") variable is used to capture the substance of these qualitative explanatory variables. Categorical variables indicate the condition or state of the non-quantifiable data, taking on a value of either 0 or 1, depending on the existence of its explanatory status. Table 4-3 on the following page itemizes the domain of installation explanatory variables initially implemented in model formulation.

A general criterion for selecting explanatory variables for regression analysis is that the causal relationship between the dependent and explanatory variable makes intuitive sense to both the analyst and the end user. Once the causality condition is satisfied and a given set of explanatory variables is assembled, the formidable task of uncovering the most statistically relevant variables must be addressed. Through continual calculational regression iterations and statistical significance analysis employing numerous combinations of data variables, the optimal blend of explanatory variables can be determined. It is important to recognize that regression analysis is not designed to identify explanatory variables that have been omitted from the model, but rather to determine the statistical significance of the variables present. In this regard, an exhaustive collection of data variables such as shown in Table 4-3 is a judicious choice for initial model generation.

QUANTITATIVE		QUALITATIVE	
*Variable**	*Symbol*	*Variable*	*Symbol*
Total Number of Sites	Sts(T)	Installation NPL Status	NPL
Sites w/ Study Phase Complete	Sts(S)-c	Installation FFA/IAG Status	FFA
Sites w/ Study Phase Underway	Sts(S)-u	Installation EBS status	EBS
Number of IRAs Complete	Sts(A)-c	Installation Location (State)	CA?
Number of IRAs Underway	Sts(A)-u	Installation Type	TYPE
Sites w/ Design Phase Complete	Sts(D)-c	Re-Use Plan Status	R/U
Sites w/ Design Phase Underway	Sts(D)-u	Operational Status	OP?
Sites w/ Cleanup Phase Complete	Sts(C)-c		
Sites w/ Cleanup Phase Underway	Sts(C)-u		
Sites with Response Complete	Sts(RC)		
Installation Acreage	InstA		
Excess Acreage	ExcA		
Unsuitable Acreage	UnstA		
% Unsuitable Acreage	%Unst		
Estimated Years-to-Completion	YTC		
Years Restoration Costs Incurred	YRCI		
**Sites w/ Relative Risk - High	Sts(H)		
**Sites w/ Relative Risk - Medium	Sts(M)		
(*): Data are "per installation"			
(**): Data for FY95-FY96 only			

Table 4-3. List of Explanatory Variables Employed in Regression Modeling

The selection of quantitative and qualitative explanatory variables was a function of both the availability of employable data and the ability to mathematically translate the real-world factors that drive environmental restoration costs. As previously mentioned, the choice of the quantitative variables was relatively straightforward, primarily driven by the data available from the DERP and NAVFACENGCOM. In addition to the strict employment of raw quantitative values, data manipulation of the quantitative variables included the logical mathematical combination of parameters to yield additional explanatory values. For example, the variable "% Unsuitable Acreage" (%Unst) was derived by subtracting the available raw values of "Suitable Acreage" from "Excess Acreage" divided by "Excess Acreage".

In contrast to quantitative variable selection, the designation of qualitative variables was less obvious and more subjective in nature. In general, the choice of qualitative variables originated principally from literature research on the determinant events in the environmental restoration process and from consultations with NAVFACENGCOM personnel familiar with the drivers of restoration activities and the flow of funding. A brief bulletized description of each of the qualitative explanatory variables employed in forecast model formulation are outlined below.

- <u>Installation NPL Status (NPL)</u>. The very nature of an installation's inclusion on the NPL demands increased restoration effort prioritization. Additionally, it is postulated that once an NPL installation has been placed on a BRAC list, restoration efforts would receive even higher prioritization to mitigate the stigma associated with a Superfund site and thus, enable prompt property transfer/re-use.

- <u>Re-Use Plan Status (R/U)</u>. Re-Use plan generation involves many groups, most notably community development officials. According to DoN restoration personnel, a BRAC facility with a well developed R/U plan is more inclined to receive higher priority in both restoration activity and resource allocation in order to maximize the benefits of the BRAC process by expediting land turnover.

- Installation FFA/IAG Status (FFA). A Federal Facilities Agreement (FFA) specifies the roles and responsibilities of the regulatory agencies and DoD, as well as, establishing milestones for future cleanup actions. Early involvement of regulatory agencies via FFAs ensures concurrence and enhances credibility of DoD actions. DoD seeks this cooperative and collaborative effort to avoid complications late in the process that could result in costly delays and rework.

- Installation EBS Status (EBS). The Environmental Baseline Survey (EBS) is the DoD process utilized to evaluate and identify a parcel's environmental condition. The EBS defines seven Area Types for categorizing of property. It is this characterization that serves as the conclusive property status document required for government real estate transactions under the Findings of Suitability to Lease (FOSL) and Findings of Suitability to Transfer (FOST) programs.

- Installation Location (CA?). Due to the growing conduct of coordinated restoration efforts with Federal, state, and local authorities, non-DoD regulators tend to dominate restoration requirements. Generally, the localities with relatively stricter regulatory mandates demand more extensive restoration effort. In this regard, literature research and discussions with federal restoration personnel invariably highlight the state of California as being distinctly stringent on environmental restoration requirements.

- Installation Type (TYPE). Intuitively, the character of past operations, engendered in the type of installation, greatly shapes the amount and type of restoration effort. Restoration research and counsel with NAVFACENGCOM personnel point toward Naval Air Stations (NAS) as the most environmentally challenging cleanup endeavors. The best explanation for this phenomenon may be both the relatively statistically larger size (acreage) of NAS's and the unique type of aviation contaminants, driving costly remediation for soil and groundwater contamination.

- Operational Status (OP?). This variable was conceived in order to unveil whether operational status affects the rate and/or timing of environmental restoration resource consumption. The presumption was that facilities that are no longer operating are able to focus more exclusively on restoration activities. Additionally, the tracking of operating status serves as a surrogate measure for advance along the BRAC time line.

The actual regression model process and statistical results are detailed in Sections D and E of this chapter. Additionally, a comprehensive breakdown of each DoN BRAC facility and its corresponding dependent and explanatory variable data is given in Appendix A.

An interrelated primary objective of thesis research is the derivation and quantification of the measurable effects of a BRAC initiation on a facility's key parameters. In establishing these BRAC initiation effects on installation parameters, all available data for DoN BRAC facilities, including the earlier years of FY89-FY93, were incorporated without restriction. A listing of those facilities and the parametric variables measured is detailed in Chapter V.

C. FORECASTING MODEL FORMULATION

The application of mathematical and statistical methods to analyze and forecast economic measurements is commonly referred to as Econometrics [Ref. 35]. In this regard, the econometric method of multiple regression is one of the most popular and versatile estimating procedures in the analysis of non-experimental economic data [Ref. 36]. Specifically, multiple regression is a technique for quantifying relationships and causality among multiple variables. Multiple regression is concerned with quantitatively describing and predicting the value of one dependent variable on its interaction with several explanatory or, independent, variables.

Regression analysis is a statistical instrument applied to develop a mathematical relationship between econometric variables and to determine the statistical significance of the variables under analysis. The multiple regression output is an algebraic model depicting an equation for the expected value for the dependent variable given specific values for the explanatory variables. The general form of the regression equation is given below.

$$\boxed{\mathbf{Y} = \mathbf{a} + b_1{*}\mathbf{X}_1 + b_2{*}\mathbf{X}_2 + b_3{*}\mathbf{X}_3 + \ldots\ldots}$$

In this standard regression equation, the **Y** term represents the dependent variable; the **a** term is the linear intercept or "constant"; the **X** terms represent the explanatory variables; and the **b** terms are the coefficients of partial regression. The **b** terms are interpreted as the average change in the dependent variable (**Y**) with a unit change in the adjoining explanatory variable (**X**), assuming all other explanatory variables remain constant. The derived constant values for the **a** and **b** terms are utilized in the equation for various combinations of explanatory **X** variables to predict a quantitative value for the dependent **Y** variable.

When evaluating the statistical results of a multiple regression calculation, there are four central measures of goodness of fit that determine the significance and accuracy of the regression output. The four goodness of fit measures - Standard Error of Estimate (S); t-ratio; F-statistic; and the Coefficient of Determination (R-Sq) - are briefly profiled below.

- <u>Standard Error of Estimate (S)</u>. The Standard Error measures the vertical distance from the sample data points to the computed regression line thus enabling examination of the data dispersion about the estimating equation. The value of the Standard Error is akin to the value of standard deviation in a normal distribution. For ascertaining goodness of fit, a *smaller* Standard Error value is considered superior to a higher value.

- <u>The t-ratio</u>. The t-ratio demarcates statistical significance for explanatory variable coefficients of the regression line. The resultant individual explanatory variable t-ratios must meet or exceed a statistical critical value to be considered significant. For a 95% confidence level, a variable's t-ratio must be greater than or equal to an absolute value of roughly 2.0 to merit further model inclusion. Generally, the *higher* the t-ratio is above 2.0, the more statistically significant the explanatory variable.

- <u>The F-ratio</u>. The F-statistic tests the sufficiency of the regression model as a whole by measuring how robustly the entire selected combination of explanatory variables characterize the system being analyzed. If the computed F-ratio is less than the statistical critical value (roughly 4.0 for a 95% confidence level), then the selected combination of explanatory variables does not reliably capture the system under test. A *higher* F-statistic suggests a more statistically significant regression model.

- Coefficient of Determination (R-Sq). The Coefficient of Determination measures the percent variability of the dependent variable that can be explained by the regressed combination of explanatory variables. Values for R-Sq range from 0.0% to 100%, with a *higher* percentage denoting a model with greater explanatory power. Even though the statistical significance of R-Sq is assessed using the F-ratio, the analyst must rationally conclude an acceptable numerical R-Sq threshold above which definitive conclusions can be drawn.

The multiple regression forecasting process conducted on the accumulated data is detailed in Sections D and E that follow. The forecast model designs, resultant mathematical equations, and statistical results are to be interpreted utilizing the terms discussed above.

D. FORECASTING MODEL METHODOLOGY

In creating a realistic and reliable forecast model, the explicit objective is to construct a multiple regression model relating environmental restoration costs to several decisive explanatory variables. Since there is no certifiable link between environmental restoration costs and any exclusive set of installation variables, the regression model approach must necessarily be an empirical endeavor. To assure complete and conclusive results, an exhaustive set of explanatory variable candidates likely to influence environmental restoration costs was assembled to systematically construct the forecast model and to test its adequacy of fit.

Prior to executing any of the countless regression runs, the data distribution for each of the dependent variables was examined to determine its geometry. In order to maximize the precision of multiple regression, the dependent variable must be nearly symmetric in distribution since confidence intervals and tests of statistical significance are based on the assumption that the dependent variable is normally distributed. For each of the study's dependent cost variables, the histogram profiles exhibited an asymmetric distribution. To correct such a phenomenon, common practice is to adjust empirical data using mathematical transformations in order to provide a more symmetric distribution. Specifically in the case of the restoration cost variables, a logarithmic ("logt") transformation proved the most effective adjustment to each of the data distributions. A particular example of the dependent variable data transformation effects is illustrated in Appendix B.

At the outset, the model formulation strategy consisted of regressing each of the dependent variable candidates - Total Cost ($TC); Investigation Cost ($IC); and Cleanup Cost ($CC) - on *all* the explanatory variable candidates. This total variable inclusion approach was adopted primarily to ensure no fundamental causal variables were omitted from the model. As a statistical mechanism, the method permitted examination of the individual partial regression coefficients in order to make preliminary judgements about the importance of each explanatory variable. The initial models also served as the basis for statistical comparison to all successive regression revisions.

From the all-encompassing initial regression models, systematic statistical reduction continued, one explanatory variable at a time, until all remaining variables were statistically significant (i.e., each partial regression coefficient t-ratio absolute value is greater than the critical values necessary for significance at the 95% confidence level). Parallel to the t-ratio analysis, each successive regression was evaluated on its performance in improving overall model significance. This assessment was accomplished by comparing F-statistics, Coefficients of Determination (R-Sq), and Standard Error of Estimates (S) in each ensuing regression run.

In addition to the goodness-of-fit measures explained in Section C above, several auxiliary tests were conducted to confirm the validity of the regressed solution. The additional tests assist in verifying the maintenance of critical regression model assumptions. The specific verifications attempted in regression formulation include tests for: linearity and homoscedasity (Residual versus Fit plots); the normality of error distribution (Normal Probability plot); autocorrelation (Durbin-Watson Test); experimental lack of fit (XLOF test); and explanatory variable correlation (CORR test). The actual numerical and graphical results for the model validation tests conducted in the final regression are provided in Appendix B.

All of the multiple regression computations and analytical tests were performed using the commercially produced MINITAB Statistical Analysis software package. The data and graphical representations in Appendix B are outputs of the MINITAB system. Brief explanations accompany some of the data and graphics in Appendix B to help clarify the relevance of the presentations.

E. FORECASTING MODEL RESULTS AND ANALYSIS

Each dependent variable underwent the comprehensive regression model formulation process to ensure all plausible combinations of installation data were incorporated. Table 4-4 on the following page summarizes the multiple regression outcomes for the best combination of explanatory variables for each of the dependent variables. The regression results for each dependent variable are further clarified in the subsections that follow.

Dependent Variable	F-statistic	R-Sq	S
logt ($TC)	18.57	75.1%	0.2143
logt ($IC)	12.86	67.7%	0.2591
logt ($CC)	9.47	46.8%	0.6552

Table 4-4. Final Regression Results for FY94-96 Data on Each Dependent Variable

1. Total Cost ($TC) Regression

Evident from the statistics in Table 4-4 above, the regression method employing the dependent variable of Total Cumulative Environmental Restoration Cost (Total Cost ($TC)) resulted in the most significant forecasting model. Interpretation of the resultant regression outputs show that the model utilizing transformed Total Cost ($TC) features the most preferred result combination of highest F-Statistic, highest R-Sq, and lowest Standard Error of Estimate (S). Deserving of particular mention is the surprisingly substantial value for the Coefficient of Determination (R-Sq) given the purely empirical nature of the regression data. An R-Sq value of 75.1% implies that 75% of the variation in Total Cost ($TC) is captured and explained by the assembled dependent variables. Chapter VI will fully reveal the entire $TC resultant regression equation and describe a spreadsheet implementation method.

Of the 25 explanatory candidates included in the initial Total Restoration Cost ($TC) regression model runs, only seven installation variables proved statistically significant for forecasting purposes. The final set of seven explanatory variables contained three quantitative and four qualitative variables. Table 4-5 on the following page lists the regression statistics and briefly restates the descriptions for each of the seven explanatory variables. Due to the necessary transformation of the dependent variable in regression model formulation, the interpretation of the stated variable coefficients (Coeff) must be considered with respect to the non-linear nature of the regression. Chapter VI details the linear conversion of the data to yield results in terms of standardized installation parametric values.

VAR	t-ratio	Coeff	Explanatory Variable Description
Sts(T)	4.88	0.01417	Total Number of Sites on Installation
UnstA	3.90	0.00012	Unsuitable Acreage - (Excess Acreage minus Suitable Acreage)
Sts(C)	2.42	0.03877	Sum of Sites w/ Cleanup Phase Complete or Underway
CA?	4.31	0.31660	Installation Location (State) - (variable=1 if state was California)
R/U	4.10	0.26135	Re-Use Plan Status - (variable=1 if definite R/U plan during FY)
FFA	-4.05	- 0.4597	Installation FFA/IAG Status - (variable=1 if agreement during FY)
NPL	3.56	0.42930	Installation NPL Status - (variable=1 if on NPL during FY)

Table 4-5. Resultant Significant Forecasting Model Explanatory Variables for $TC

2. Investigation Cost ($IC) Regression

The equally significant results from the regression on Total Cumulative Investigation Cost ($IC) suggest a meaningful correlation between Investigation and Total Restoration Cost. This cost association has its roots in actual restoration practices. Despite the recent crossover of cleanup activities versus investigative actions, the predominant driver of Total Cumulative Restoration Cost to-date is in the Investigation Cost category. In fact, for the cost data compiled in this study, Investigation Cost constituted nearly 80% of Total Cost.

3. Cleanup Cost ($CC) Regression

In contrast to the clear correlation between Investigation Cost and Total Costs, the best possible regression on Total Cumulative Cleanup Cost produced markedly less significant results. Aside from the explanation that cleanup category actions have lagged investigative actions, the lower Cleanup Cost regression results suggest important inferences about the usability of empirical parametric cleanup activity data. In fact, what may seem intuitively obvious is confirmed by the results of these comparative regressions. That is, cleanup activities are far more complex and variable than other restoration activities and thus the analysis of historical parametric data for Cleanup Cost is less likely to predict future cleanup-specific activity costs. In other words, most of the unexplained variance in environmental restoration cost forecasting can be attributed to the mercurial nature of cleanup activities and the lack of substantial historical data on full-completion cleanup actions.

4. Comparing Regression Results

Further comparison of the regression results for each of the three different dependent variables highlighted the common cost drivers in every model. Four explanatory variables - Total Sites (Sts(T)); Sites with Cleanup Phase work complete or underway (Sts(C)); Installation NPL Status (NPL)); and Status of Re-Use plan (R/U)) - were significant factors in each dependent variable regression, suggesting that these four installation parameters are the most universally applicable cost drivers for any type of environmental restoration cost being studied or estimated.

In comparing the less volatile Investigation Cost and Total Cost regressions, all seven explanatory variables listed previously in Table 4-5 were statistically significant in both cases. Of note, the Installation Type (TYPE) explanatory variable was only slightly below the statistical critical value in both the Total Cost and Investigation Cost regressions. Table 4-6 below summarizes the relevant explanatory variables that are statistically significant in each dependent variable regression.

Explanatory Variables	$TC	$IC	$CC
Sts(T)	X	X	X
UnstA	X	X	
Sts(C)	X	X	X
R/U	X	X	X
CA?	X	X	
FFA	X	X	
NPL	X	X	X

Table 4-6. Summary of Statistically Significant Explanatory Variables

5. Incorporating Relative Risk

In an attempt to facilitate inclusion of Relative Risk Site Evaluation parameters, additional regressions were performed on each dependent cost variable. DoD's Relative Risk Site Evaluation framework is intended to adjust environmental restoration goals based on a site prioritization basis. Reduced funding levels command DoD to more effectively direct its limited resources to sites that pose the greatest threat to human health and the environment.

The Relative Risk strategy assigns each potentially contaminated site to a high, medium, or low risk category. In determining the categorization, the Relative Risk procedure addresses several site characteristics, including: specific contaminants present; the significance of contamination; contaminant migration pathways; and human and ecological receptors located near the site.

Due to the recent implementation of the Relative Risk program, the regressions including Relative Risk data utilized only FY95 and FY96 data. Employing the identical formulation process used to build the more inclusive FY94-FY96 model, each dependent variable underwent a similar comprehensive regression procedure to ensure all plausible combinations of installation data were incorporated. Each regression's statistical results for FY95-96 data were encouragingly similar to the results of the full data (FY94-FY96) regression statistical outcomes. As in the full data regressions, the most statistically significant results proved to be the regressions on Total Cost ($TC). The multiple regression outcomes for the FY95-FY96 data runs are summarized in Table 4-7 below.

Dependent Variable	F-statistic	R-Sq	S
logt ($TC)	14.78	76.7%	0.1916
logt ($IC)	10.97	52.3%	0.2874
logt ($CC)	8.38	47.3%	0.5330

Table 4-7. Final Regression Results for FY95-96 Data on Each Dependent Variable

Although the FY95-FY96 regression results go a long way in supporting the robustness of the full FY94-FY96 data regression model, an additional major research finding is the real success of the FY95-FY96 data test. In each of the regressions on the dependent variables, all of the models produced results *devoid* of the high priority Relative Risk parameters - High Priority Sites (Sts(H)) and Medium Priority Sites (Sts(M)) - as statistically significant explanatory variables. In fact, the Relative Risk data were not even marginally significant in any of the iterative regressions.

The statistical insignificance of the Relative Risk data in forecast model formulation may be interpreted in two general ways:

- The cost effects of the Relative Risk measures are already captured by some of the variables resident in the developed forecast model and thus, the Relative Risk measures become redundant and insignificant variables.
- The Relative Risk program may not be properly constructed due to being an *a priori* measure based on supposition rather than an empirically based measure.

When analyzing the Relative Risk program and the developed forecast model it seems that Relative Risk characterization procedures (described previously) include assessments on installation parameters *not* captured by the developed forecast model variables. As a result, the second interpretation of Relative Risk insignificance (see above) appears more accurate. However, with the recent (FY95) implementation of Relative Risk Site Evaluation, the use of only the first two years of program data may not be indicative of the future significance Relative Risk plays in driving environmental restoration costs. Further research should focus on the Relative Risk Site Evaluation initiative to ensure it is meeting its intended purpose.

F. SUMMARY

To achieve the primary thesis objective of constructing a comprehensive, inclusive, and functional environmental restoration cost forecasting model, substantial amounts of installation parameters required rigorous data management and anlysis. To this end, over 25 separate installation statistical parameters were compiled for each of the qualifying 17 DoN BRAC facilities over the most recently available three year period (FY94-FY96). A multiple regression technique was employed to manage the extensive data and construct the forecast model. Multiple regression is a multifaceted estimating method, quantifying relationships and causality among multiple variables in the analysis of empirical data.

The most tenable and statistically significant forecast model was the regression of the transformed dependent variable of Total Cost ($TC). By an iterative regression process, a final combination of seven explanatory installation variables (highlighted in Table 4-5) proved to be the most meaningful restoration cost drivers. The developed $TC regression model resulted in an R-Sq statistical value of 75.1%, implying that 75% of the variation in Total Cost ($TC) is captured and explained by the assembled dependent variables.

Comparison of the regression results for each of the three different dependent variables reveals the common cost drivers in every model. Four explanatory variables - Total Sites (Sts(T)); Sites with Cleanup Phase work complete or underway (Sts(C)); Installation NPL Status (NPL)); and Status of Re-Use plan (R/U)) - were significant factors in each dependent variable regression, suggesting that these four installation parameters are the most universally applicable cost drivers for any type of environmental restoration cost being studied or estimated.

What is equally as important, and no less interesting, is the explanatory installation variables that proved statistically insignificant in explaining the dependent variable cost variations. The most striking of the non-significant explanatory variables, as detailed in the section above, include the Relative Risk Site Evaluation program data.

V. EFFECTS OF BASE REALIGNMENT & CLOSURE INITIATION

A. INTRODUCTION

The effects of a Base Realignment and Closure (BRAC) action on an installation are multifarious and far-reaching. All facets of the affected facility, from daily operations and manning to environmental parameters, are thrust into a state of dynamic transformation. The scope of change at a facility is never uniform or consistent in its timing. Of particular thesis research interest are the magnitude and timing of changes to environmental restoration parameters as a result of BRAC initiation. It is postulated that the initiation of a base closure or realignment action rapidly accelerates a facility's environmental restoration timetable and thus begets a discernible increase in expenditure rate and resource consumption.

The aim of this chapter is to fulfill the second primary thesis objective of determining the key installation parameters that appear sensitive to the initiation of BRAC. In attempting this quantification of parametric change, the full range of available parametric data (FY89-FY96) was employed on a full range of DoN BRAC facilities. As mentioned in Chapter III, a preponderance of DoN facilities had some level of environmental restoration data available through the DERP prior to being placed on a BRAC list. Specifically, the data compiled consisted of environmental restoration parameters for all major and minor DoN closures and realignments for BRACs I through IV. The data were analyzed to determine:

- General effects experienced by installation parameters after BRAC initiation
- The timing of the noticeable parametric effects
- Effects related uniquely to the type of BRAC action (i.e., closure vs. realignment)

The remainder of this chapter is divided into five sections. Section B briefly outlines the established regulatory BRAC timelines that ostensibly influence environmental restoration activities. Section C describes the pool of installation data utilized to establish empirical BRAC parameter effects. Section D details the results of data comparison on the historical parameter changes experienced by facilities following the inception of base closure or realignment proceedings. Section E provides a chapter summary, highlighting the empirically determined BRAC parameter delta "rules of thumb" to be considered in the forecasting of environmental restoration expenditures.

B. INFLUENCE OF BRAC TIMELINES ON RESTORATION ACTIONS

Of considerable consequence to the implementation of BRAC proceedings are the legal and regulatory requirements governing the timing of BRAC environmental restoration operations. In order to accurately examine the effects of BRAC initiation on a facility's environmental parameters, it is crucial to understand the sequence of events and the time period in which those events occur. Generally speaking, there is a discernible lag between the enactment of a BRAC list and the subsequent BRAC-related environmental restoration activities performed at a newly affected installation. A notional BRAC timeline is portrayed in Table 5-1 on the following page to underscore the occurrences of environmental restoration actions as sequenced to the official BRAC recommendation date of approval. Timeline structuring was gleaned from the Department of the Air Force Base Closure Agency's Base Closure Timeline Fact Sheet [Ref. 38].

Month, FY	Regulatory Requirement	Regulatory Description
SEP,XX	BRAC XX List Approval	Expiration of Congressional Disapproval Authority (45 days after submission)
OCT,XX+1	DoD Notice of Availability of Property to Federal Agencies	Federal Agencies and other military services have initial access to property
DEC,XX+1	Federal Agency applications submitted for property transfer	Within 60 days of availability notice
JAN,XX+1	DoD publishes excess/surplus property listings	Within 100 days of availability notice
MAR,XX+1	DoD holds community Re-Use and Redevelopment seminars	6 months after BRAC list approval date
JUN,XX+1	Time period for submission of property notices of interest	Within 6 months of publishing excess/ surplus property in Federal Register
MAR,XX+2	DoD completes identification of uncontaminated parcels	18 months after BRAC list approval (CERCLA mandated)
MAR,XX+2	Community Re-Use and Re-development plans due to DoD	Within 9 months after completion of submitted property notices of interest
AUG,XX+2	DoD officially initiates BRAC activities	Within 2 years after Presidential approval of BRAC list
MAR,XX+3	DoD completes Environmental Impact Statement (EIS)	12 months after community Re-Use and Redevelopment plan submittals
AUG,XX+6	DoD officially completes BRAC activities	Within 6 years after Presidential approval of BRAC list

Table 5-1. Notional BRAC Timeline for Environmental Restoration Activities

It becomes clear after examination of Table 5-1, that the critical environmental restoration events of determining excess/surplus property, establishing Re-Use committees, identifying uncontaminated parcels, officially initiating BRAC actions, and completing Environmental Impact Studies, occur some time after the BRAC list has assumed force of law. As will be detailed in Section D of this chapter, the accompanying restoration actions of the later occurring environmental milestones translate to a lagged effect on parameter changes and restoration expenditures. By way of example, the initiation of BRAC IV in September of 1995 (FY95) did not result in explicit BRAC-related installation parametric effects and related expenditures in some instances until FY97, and a majority of the remediation may not be concluded until as late as FY01.

To fully capture the consequences of BRAC initiation and thus facilitate reliable forecasting, the timing and disposition of BRAC environmental actions must be coupled with the changing parametric effects. Understanding when and over what period to apply projected changes in installation parameters is vital to the credibility of the predictive strength of the forecasting method.

C. DATA DESCRIPTION FOR BRAC-RELATED PARAMETRIC EFFECTS

In an attempt to establish and quantify the effects of BRAC initiation on a facility's environmental parameters, the full range of available parametric data was employed on a full range of DoN BRAC facilities. The analysis of parametric change encompassed the available installation data for FY89 through FY96. Table 5-2 on the following page lists the 42 DoN installations utilized for this effort. To be included in this focus group, each facility was required to have data available in each of the years under study. Due to the less sophisticated and less restrictive nature of this analysis, the number of facilities in this parametric change research effort is considerably more inclusive than the forecast model generation effort.

INSTALLATION	INSTALLATION
Adak Naval Air Facility	Lakehurst Naval Air Engineering Center
Agana Naval Air Station	Long Beach Naval Station
Alameda Naval Air Station	Long Beach Naval Shipyard
Barbers Point Naval Air Station	Mare Island Naval Shipyard
Barstow Marine Corps Logistics Base	Memphis Naval Support Activity
Cecil Field Naval Air Station	Midway Naval Air Facility
Charlseton Naval Shipyard & Naval Station	Moffett Field Naval Air Station
Chase Field Naval Air Station	Newport Naval Education and Training Center
Corpus Christi Naval Air Station	Oakland Fleet and Industrial Supply Center
Dallas Naval Air Station	Orlando Naval Training Center
Davisville Naval Construction Battalion Center	Philadelphia Naval Complex
Driver Naval Radio Transmitting Facility	San Diego Naval Training Center
El Toro Marine Corps Air Station	Sand Point (Puget Sound) Naval Station
Glenview Naval Air Station	Salton Sea Test Range
Guam Naval Activities	Seal Beach Naval Weapons Station
Guam Naval Ship Repair Facility	South Weymouth Naval Air Station
Guam Fleet and Industrial Supply Center	Treasure Island Naval Station
Guam Public Works Center	Trenton Naval Air Warfare Center
Hunters Point Annex Naval Station	Tustin Marine Corps Air Station
Keyport Naval Undersea Warfare Center	Warminster Naval Air Warfare Center
Key West Naval Air Station	White Oak Naval Surface Warfare Center

Table 5-2. DoN BRAC Installations Employed in BRAC Parametric Effects Analysis

In addition to evaluating DoN BRAC facilities, three supplementary installation sets were established in order to provide comparative parameter trend baselines. The first installation set consisted of all DoN non-BRAC facilities that were on, or proposed to be on, the EPA's National Priorities List (NPL). The purpose of this facility grouping was to provide a restoration-intensive parametric trend baseline against which changes in DoN BRAC installation data could be compared. Each of the 20 installations compiled in this set had to meet not only the condition of being a non-BRAC NPL facility, but also had to have the requisite parametric data available for the FY89-FY96 time period. A representative mix of both USMC and USN facilities are included in this set, embodying many varied installation types. The two remaining baselining installation sets consisted of "total" DoN data measures (of which the BRAC and non-BRAC facilities are subsets) and "total" DoD data measures (includes data from all the services and the Defense Logistics Agency). All four installation sets are summarized in Table 5-3 below.

Installation Set	Installation Set Description
DoN BRAC	DoN BRAC facilities with DERP data for period FY89-FY96
DoN Non-BRAC	DoN non-BRAC facilities on, or proposed to be on, the NPL
Total DoN	Totality of DoN's restoration efforts as reported by the DERP
Total DoD	Totality of DoD's restoration efforts as reported by the DERP

Table 5-3. Installation Sets Employed in BRAC Parametric Effects Analysis

The parameters measured for each installation set consisted of restoration data covering DoN closures and realignments for BRACs I through IV. It should be noted that the Navy was only marginally influenced by BRAC I (eight affected facilities), with only three facilities receiving any environmental restoration action. Due to this small data pool, no meaningful analysis can be garnered from exclusively studying BRAC I facilities. The affected three sites, however, are included in the overall DoN BRAC installation set analysis.

The choice of the actual parameters compiled and analyzed centered largely on, but was not limited to, those variables deemed significant restoration cost drivers during forecast model formulation. The specific installation set variables measured are itemized in Table 5-4 below. As was the case in forecast model formulation, the quality and quantity of data increased appreciably in the out years, especially in the FY94-FY96 period.

EXPLANATORY VARIABLES	
Variable	*Symbol*
Total Number of Sites	Sts(T)
Number of IRAs Complete or Underway	Sts(A)
Sites w/ Design Phase Complete/Underway	Sts(D)
Sites w/ Cleanup Phase Complete/Underway	Sts(C)
Sites with Response Complete	Sts(RC)
Unsuitable Acreage	UnstA
Installation FFA/IAG Status	FFA
Re-Use Plan Status	R/U

Table 5-4. Installation Variables Measured in BRAC Parametric Effects Analysis

D. ANALYSIS RESULTS FOR BRAC-RELATED PARAMETRIC EFFECTS

Including the inherent dynamic nature of environmental restoration efforts, the establishment of reliable parametric trends for installation data over the FY89-FY96 faced several notable challenges throughout the research process. Three of the unique impediments to stable trend analysis included DoD's adoption of a new installation restoration activity tracking system in FY92, the impact of implementing the Fast-Track Initiative, and the non-trivial refinement of DoN installation data in FY95. Each one of these elements corrupted consistent trend establishment in various ways and to varying degrees, as described below.

- During FY92, DoD developed an improved system - the Restoration Management Information System (RMIS) - for enhanced tracking of restoration activities. A majority of DoD's cleanup work by FY92 was aimed at stabilizing sites that posed the greatest dangers to health and the environment. This stabilization work involved Interim Remedial Actions (IRAs) that were not separately accounted for prior to FY92. [Ref. 39] As a consequence, reporting was initiated for the new category of IRAs and the previously reported category of Remedial Actions (RAs) was adjusted significantly downward to account for the segregation of IRAs.

- The inclusion of an additional site category, coupled with improved information management, led to an abrupt program-wide increase in FY92 Total Sites (Sts(T)). The impact to DoN was even more pronounced, perhaps due to the Navy's considerable use of Interim Remedial Actions (IRAs) in the unique wetlands, estuarine, and marine environments adjacent to DoN installations [Ref. 40].

- As stated in Chapter II, the most critical recent environmental restoration initiative was born out of the President's 1993 five part Community Reinvestment Program. The Fast Track Cleanup Initiative, one of five major initiatives in the plan, was a leading force in DoD environmental restoration endeavors beginning in FY94. DoD immediately developed several Fast Track implementation strategies to focus each service on accelerating environmental restoration progress [Ref. 41].

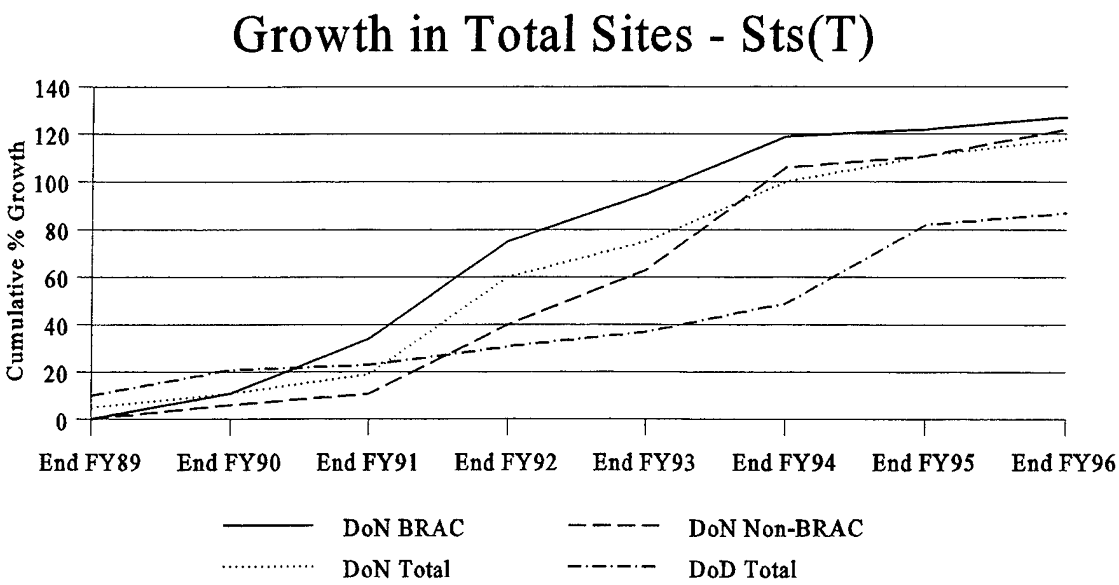
- DoN data underwent a larger than normal refinement in FY95 to revise parameter totals that were previously categorized incorrectly after having discovered some duplicative accounting and inappropriate classification of actions based on strict BRAC program definitions [Ref. 42]. Although all DoN facilities were affected, BRAC parameters appeared to bear the weight of the adjustments.

For each of the explanatory variables listed in Table 5-4, installation parametric data were compiled for each installation set over the maximum number of years figures were available. From the compilation of raw data, a yearly growth rate (Per Year % Growth) and a cumulative growth rate (Cumulative % Growth) were calculated for each installation set in order to establish individual installation set trend lines.

In general, the DoN BRAC installation set was compared to the other three sets to evaluate the parametric effects over time, if any, of BRAC proceedings. Not only was the DoN BRAC installation set evaluated as a whole, but data for BRAC rounds II, III, and IV were individually evaluated to ascertain any specific timing effects. The year immediately preceding BRAC initiation and the three subsequent years following BRAC initiation were focused on in the comparative analysis. The subsections that follow specify the results of the comprehensive trend analysis on the key installation parameters.

1. Total Number of Sites - "Sts(T)"

An installation's Total Number of Sites - Sts(T) - proved to be the most significant quantitative explanatory variable in forecast model formulation and thus is a meaningful parameter in predicting environmental costs at DoN BRAC facilities. As a result, Sts(T) was examined to measure the effects of BRAC proceedings in order to better predict its contribution to forecast model estimations. Graph 5-1 on the following page charts the cumulative yearly growth rate (Cumulative % Growth) in Sts(T) at each of the four installation sets.



Graph 5-1. Cumulative Yearly Growth for Sts(T) Parameter

The most general observation that can be made from Graph 5-1 is that as the BRAC process matures, the growth of DoN BRAC sites outpace the other three installation sets in the out years after having lagged behind in the early research years. Intuitively, this result is expected, considering the relative undeveloped nature of the BRAC process in the earlier study years coupled with the more recent interest in BRAC progress as the regulatory timeline requirements become decisive.

A more detailed analysis of individual yearly growth rates reveals important features of the environmental restoration program affecting multiple installation sets in this, and other, parameter evaluations. For example, the abrupt increase in Sts(T) for the Navy installation sets (DoN BRAC, DoN Non-BRAC, and Total DoN) in FY92 can be attributed to the aforementioned initiation of the RMIS, which divided and reclassified key site categories recurrently utilized in DoN restoration practices.

The across-the-board rise in Sts(T) during FY94 and the continued growth in FY95 has been credited to DoD's efforts in implementing the President's 1993 five part Community Reinvestment Program. DoD quickly codified the program's concepts to guide the services in rapidly altering their practices to meet the challenges set forth in the President's plan.

The apparent growth stagnation for DoN installation sets (especially the DoN BRAC set) during FY95 can be ascribed to the Navy's refinement of both BRAC and DERA site information. As highlighted previously, DoN data underwent a larger than normal adjustment in FY95 that all but eliminated any real growth in DoN Sts(T) progress. DoN revised parameter totals that were previously categorized incorrectly or erroneously duplicated. DoN BRAC parameters were the most statistically impacted.

Segregating the DoN BRAC installation set into BRAC round constituents (BRACs II, III, and IV) exposed critical facts about the timing of BRAC parametric effects. Per year growth analysis revealed that the most significant yearly gain in the Sts(T) parameter for DoN BRAC facilities occurred during the first full fiscal year following BRAC initiation. Additionally, the gain for the respective DoN BRAC installations the year following their BRAC commencement outpaced the yearly growth of all other installation sets, with the exception of BRAC III. Although BRAC III did not exceed growth of some sets in FY94 it did post its highest yearly gain since FY92. Table 5-5 on the following page highlights this particular point.

Sts(T) **%Growth**	**BRAC II**	**DoN BRAC**	**DoN non-BRAC**	**Total DoN**	**Total DoD**
FY92	40.0 %	31.0 %	26.0 %	35.0 %	6.0 %
	BRAC III	**DoN BRAC**	**DoN non-BRAC**	**Total DoN**	**Total DoD**
FY94	13.0 %	12.0 %	26.0 %	14.0 %	9.0 %
	BRAC IV	**DoN BRAC**	**DoN non-BRAC**	**Total DoN**	**Total DoD**
FY96	8.0 %	2.0 %	5.0 %	3.0 %	3.0 %

Table 5-5. Growth of Total Sites (Sts(T)) per BRAC Round.

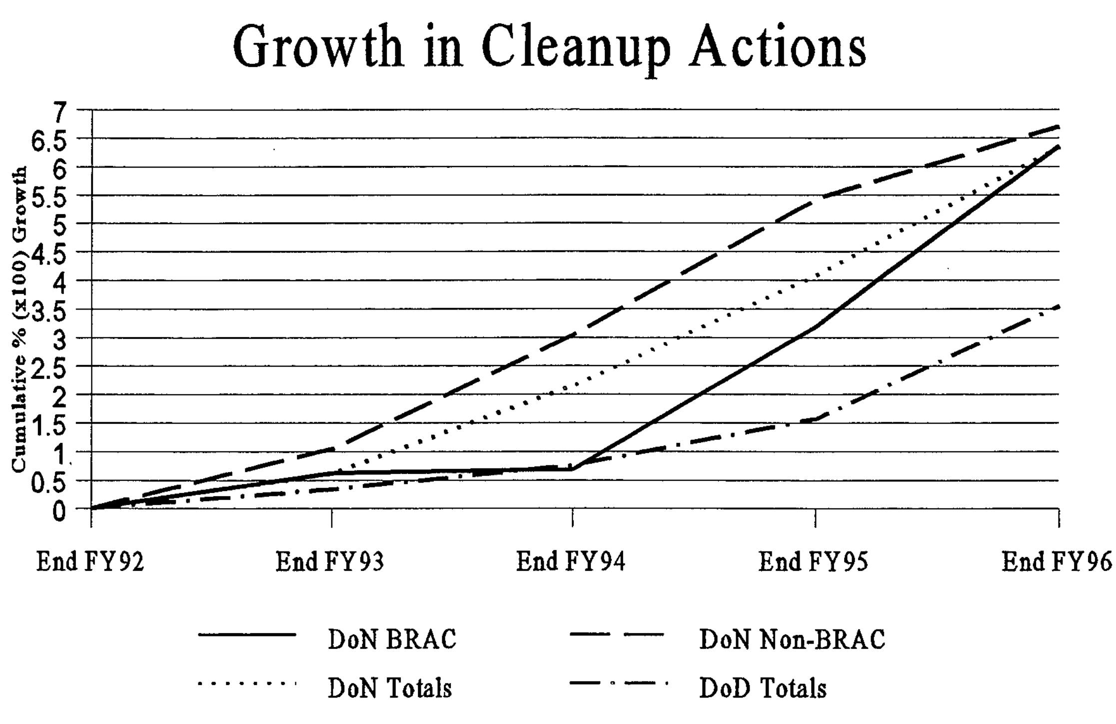
Despite the numerous restoration factors precipitating year-to-year inconsistencies, it appears that the Total Sites parameter - Sts(T) - at DoN BRAC installations grows at a greater rate when compared to any other facility set. The major unique restoration program developments and initiatives tend to affect all DoD installations in roughly similar ways, thus allowing DoN BRAC facilities to maintain their growth advantage during dynamic times.

In estimating the effects of BRAC on the Sts(T) parameter, some very general guides can be inferred from this research analysis. First, and foremost, BRAC historical data undeniably establish that the first full fiscal year after BRAC initiation is the most significant growth period for BRAC installations and generally outpaces other facilities for that year. BRAC facilities averaged roughly a 20% growth in Sts(T) in the first year following BRAC initiation as opposed to roughly a 14% growth in Sts(T) for all other installation sets in comparable years. Secondly, overall DoN BRAC growth for the FY89-96 period averaged roughly 16% compared to roughly 13% for non-BRAC facilities over the same time period.

2. Sites with Cleanup Phase Complete or Underway - "Sts(C)"

Meaningful analysis of the Sts(C) parameter included data from only FY92-FY96 due to the previously mentioned FY92-initiated RMIS tracking system. Prior to FY92, the Sts(C) category included some actions that are now classified as Interim Remedial Actions. Because of this, the Sts(C) variable dropped appreciably from FY91 to FY92 due to the adjustment.

Analyzing the growth of cleanup activities among the four installation sets demonstrates the advancing maturity level of BRAC activities. The DoN BRAC installation set has lagged the Sts(C) growth (see Graph 5-2 below) in all but the Total DoD set. The delayed growth may be attributed to the relatively less developed nature of DoN BRAC cleanup actions in light of the Navy only being significantly impacted by BRAC in FY91.



Graph 5-2. Cumulative Yearly Growth for the Sts(C) Parameter

As explained in a previous section of this chapter, the cleanup phase of a BRAC action occurs many years after the BRAC round assumes force of law but all restoration actions must be complete within six years. Consequently, it may be this impending BRAC time requirement that accounts for the recent (FY95-FY96) spikes in Sts(C) activity (see Graph 5-2 on previous page). In fact, the DoN BRAC set had the highest yearly growth rate for Sts(C) in both FY95 and FY96.

To further examine the timing issues of cleanup growth, the DoN BRAC installation set was again segregated into its BRAC round constituents, but only for BRACs II and III (being that BRAC IV occurred too recently to judge cleanup progress). Resultantly, BRAC II (FY91) showed significant Sts(C) growth starting in FY94 and peaking in FY95 (a 250% growth that year). BRAC III (FY93) showed significant Sts(C) growth starting in FY96 which is expected to continue in FY97. Additionally, both BRAC II and III DoN data significantly outpaced the Sts(C) parameter growth for all other installation sets in those peak years, as illustrated in the Table 5-6 below.

***Sts(C)* % Growth**	**BRAC II**	**DoN BRAC**	**DoN non-BRAC**	**Total DoN**	**Total DoD**
FY94	117.0 %	4.0 %	98.0 %	96.0 %	31.0 %
FY95	250.0 %	148.0 %	59.0 %	61.0 %	46.0 %
	BRAC III	**DoN BRAC**	**DoN non-BRAC**	**Total DoN**	**Total DoD**
FY96	107.0 %	76.0 %	20.0 %	45.0 %	78.0 %

Table 5-6. Growth of Cleanup Actions (Sts(C)) per BRAC Round.

In estimating the effects of BRAC on the Sts(C) parameter, it can be concluded that an initial spike in cleanup activities, as measured by progress in the Sts(C) data, occurs in the third full year following BRAC initiation. For example, BRAC II assumed force of law in FY91 but did not see a precipitous increase in cleanup activity until FY94. Similarly, BRAC III assumed force of law in FY93 but did not see its significant increase in cleanup activity until FY96. During the year of spiked activity, both BRAC facilities sets more than doubled their number of Sts(C) from the previous year.

However, a note of caution about the Sts(C) analysis is warranted. First, the inclusion of only the BRAC II and III rounds may not represent the overall BRAC cleanup trend (although BRAC III is the round that affected DoN the most and includes the bulk of the available data). In addition, the cleanup process at DoN BRAC installations is still somewhat in its infancy, having several more years to complete its cleanup requirements. Consequently, examination of cleanup data for the upcoming several years will facilitate a more confident determination of the timing and scope of DoN BRAC cleanup activities.

3. Unsuitable Acreage - "UnstA"

The Unsuitable Acreage parameter was one of the quantitative variables proved by forecast model formulation to be a significant cost driver in the restoration process. Trend analysis on this parameter was severely hampered by lack of data. Acreage data needed for the Unsuitable Acreage calculation was not available until FY94 and only then for selected installations. In fact, no data was available for any facilities within the DoN non-BRAC installation set. Resultantly, only general trend assertions can be made on the limited data.

For DoN BRAC installations, Unsuitable Acreage decreased nearly 11% over the FY94-FY96 time period. Over two-thirds of the DoN BRAC facilities experienced lower Unsuitable Acreage levels in successive years. Contrarily, approximately 10% of the DoN BRAC facilities saw a rising Unsuitable Acreage level, most likely due to site reevaluation by regulators. In contrast, the total DoN and DoD installation sets experienced Unsuitable Acreage *growth* in the FY94-FY96 period. Unsuitable Acreage growth can most readily be attributed to an increase in new "unclean" DoD facilities over the time period, coupled with the recent prioritization assigned to BRAC installation property turnover.

4. Re-Use Plan Status ("R/U") & Installation FFA/IAG Status ("FFA")

Of the four qualitative explanatory variables determined to be significant restoration costs drivers, only two - Re-Use Plan Status (R/U) and Installation FFA/IAG Status (FFA) - lend themselves to parametric trend analysis. The other two significant qualitative variables are strictly installation specific and thus are not influenced by BRAC actions or BRAC timing. Logically, this qualitative parameter analysis was confined to the DoN BRAC installation set.

Examining the R/U parameter revealed that only roughly half (20) of the facilities in the DoN BRAC installation set had tenable Re-Use Plans through FY96. Not surprisingly, the majority of facilities without Re-Use plans are from the most recent BRAC round (BRAC IV in FY95). Determining the timing for R/U data is crucial to effective estimation, considering it is one of the most statistically significant of all the qualitative explanatory variables. In regards to the timing issue, of the facilities with Re-Use plans, 10 achieved this milestone within two years and 16 within three years of BRAC initiation. The "average" time to complete a Re-Use plan was just less than 2.5 years. Conservatively, an estimating guideline of three years for the inclusion of the R/U explanatory variable within the forecast model following a BRAC initiation is the most reliable parametric trend prediction value.

The analysis of the FFA parameter produced far less clear-cut trends than did R/U variable analysis. Of the 16 DoN BRAC facilities having FFA's, only five (5) of the facilities did not also have a coinciding NPL designation. Interestingly enough, each of the five DoN BRAC non-NPL facilities with signed FFA's were in California, attesting to the premium consideration extended to cooperative efforts with what is viewed as distinctly stringent outside regulators. As far as the estimative value of the FFA variable analysis, no reliable guidelines could be adopted. The FFA explanatory variable, however, is a pivotal element of the forecast model in that its presence represents a potential cost savings versus an otherwise parametrically identical facility without such an agreement. For this reason, each facility must be evaluated on an individual basis to determine the inclusion and timing of the FFA variable in the forecast model.

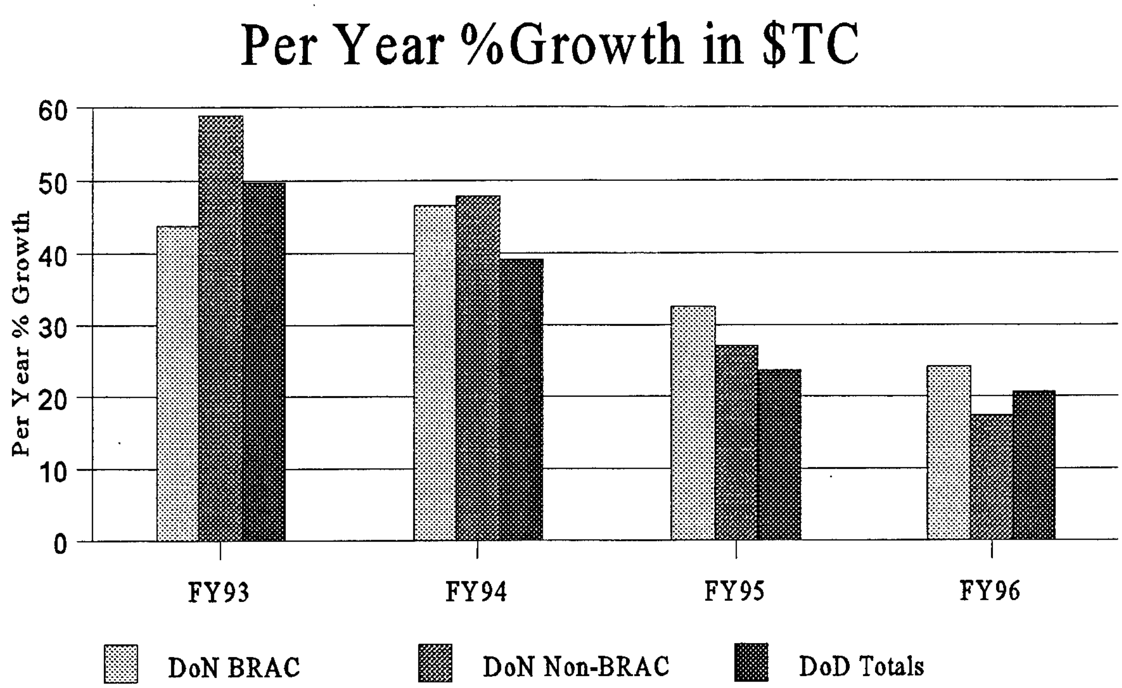
5. Additional Parametric Measures

The preceding subsections detailed the BRAC initiation trend analysis for the most meaningful explanatory variables, that is, those variables proven to be statistically significant cost drivers utilized in forecasting restoration expenditures. However, as shown previously in Table 5-4, several other variables were included in the analysis of parametric effects from BRAC initiation. Examination of the remaining variables - Interim Removal Actions (IRAs); Remedial Designs (RD); and Responses Complete (RC) - exposed many unattributable inconsistencies from year-to-year across all installation sets, perhaps explaining their lack of contribution in forecast model formulation. A broad view of these "later stage" restoration parameters over the entire study period is required to smooth the erratic trends and provide a basis for general conclusions. From this broader view, it appears the more developed and cleanup-intensive DoN non-BRAC installation set (i.e., NPL facilities) far outpaced the parameter growth of the other installation sets in these "later stage" measures. The newly emerging DoN BRAC installation set cleanup requirements translated to a comparatively lagged later stage parameter growth that was gaining substantial momentum in FY95-FY96.

6. Dependent Variables

The goal of forecast model formulation is to accurately estimate cost based on certain explanatory installation variables. In turn, the cost of environmental restoration may be the single most important determinant of programmatic trends available. One of the benefits of BRAC parametric effect trend analysis on cost data is to provide clearer evidence of program trends over time and help corroborate the assertions made about the effects on the explanatory installation parameters.

As discussed in Chapter III, the current general growth trend of environmental restoration funding is to the downside for the program as a whole. Simultaneously, there is a concerted DoD effort to assign higher priority to the more expensive cleanup actions in lieu of less costly, but more time consuming, investigative actions. The depiction of Total Cumulative Restoration Cost ($TC) per year growth in Graph 5-3 on the following page vividly illustrates both the general decreasing growth trend in funding coupled with the relative expanding growth of BRAC activities in recent years. Specifically, the rapidly increasing growth in the DoN BRAC installation set may owe its relative strength to the prioritization given to cleanup efforts, the impending BRAC timeline requirements, and heightened interest in expeditiously turning over BRAC property.



Graph 5-3. Per Year Growth in Total Cumulative Restoration Cost ($TC)

Although only $TC is represented in Graph 5-3, the Investigation Category Cost ($IC) and Cleanup Category Cost ($CC) graphical representations are nearly identical in shape, trend and relative installation set strength. Additionally, the inclusion of only the FY93-FY96 time period was necessary due to the lack of cost data for all installation sets prior to FY92. Akin to the $TC data, the $IC and $CC graphs show the general reduction in per year growth from FY93-FY96 with the DoN BRAC installation set significantly outgrowing the other sets in FY95 and FY96. Additionally, the per year growth in $CC outpaced $IC per year growth by roughly 400% in FY95 and FY96, lending credibility to DoD's recent initiative in placing greater emphasis on cleanup actions.

As was the case for explanatory variable analysis, the DoN BRAC installation set was segregated into its BRAC round constituents (BRACs II, III, and IV) to demonstrate the timing effects of the BRAC process on the dependent cost variables. In particular, the analysis of $IC and $TC provided validation for the general presumption derived from the Sts(T) evaluation. To restate the presumption, the most significant growth, and a growth that outpaces all other installations, occurs in the first full fiscal year following BRAC initiation.

Mirroring the relative growth superiority of DoN BRAC Sts(T) data in the first fiscal year following BRAC initiation, the growth of both the BRAC III and BRAC IV $IC and $TC data far outpaced the other installation sets in their respective first fiscal years following BRAC action, as depicted in Tables 5-7 and 5-8. In addition, each $IC and $TC data value listed in Tables 5-7 and 5-8 for the BRAC III and IV rounds represented their single highest yearly growth rate over the time period studied.

$IC **%Growth:**	**BRAC III**	**DoN BRAC**	**DoN non-BRAC**	**Total DoD**
FY94	53.0 %	41.0 %	27.0 %	25.0 %
	BRAC IV	**DoN BRAC**	**DoN non-BRAC**	**Total DoD**
FY96	27.0 %	13.0 %	11.0 %	9.0 %

Table 5-7. Yearly Growth of $IC per BRAC Round

$TC %Growth:	**BRAC III**	**DoN BRAC**	**DoN non-BRAC**	**Total DoD**
FY94	63.0 %	46.0 %	47.0 %	39.0 %
	BRAC IV	**DoN BRAC**	**DoN non-BRAC**	**Total DoD**
FY96	39.0 %	24.0 %	17.0 %	20.0 %

Table 5-8. Yearly Growth of $TC per BRAC Round

Analogous to previously developed cleanup activity trends, the evaluation of the Cleanup category costs ($CC) exhibited distinct BRAC-specific timing patterns in growth. Identical to the Sts(C) analysis, the BRAC II (FY91) $CC parameter experienced significant growth starting in FY94 and reach its peak in FY95. Correspondingly, the BRAC III (FY93) $CC parameter experienced significant growth starting in FY96 which, like the Sts(C) analysis, is expected to continue in FY97. Additionally, both BRAC II and III DoN $CC data generally outpaced the $CC parameter growth for most other installations in their respective peak years, as illustrated in the Table 5-9. Of note, the relative strength of the DoN non-BRAC installation set epitomizes the progress of restoration actions at matured NPL facilities.

$CC %Growth:	**BRAC II**	**DoN BRAC**	**DoN non-BRAC**	**Total DoD**
FY94	48.0 %	67.0 %	99.0 %	63.0 %
FY95	62.0 %	63.0 %	42.0 %	40.0 %
$CC **%Growth:**	**BRAC III**	**DoN BRAC**	**DoN non-BRAC**	**Total DoD**
FY96	63.0 %	49.0 %	25.0 %	32.0 %

Table 5-9. Yearly Growth of Cleanup Category Cost ($CC) per BRAC Round

7. Closure versus Realignment & Major versus Minor

To accurately characterize the effects of the BRAC process, each BRAC round subset of the DoN BRAC installation set was further subdivided into closure versus realignment facilities and major versus minor facilities. This process was undertaken to examine the independently attributable influences, if any, related uniquely to the type of BRAC action.

The comparison of closures versus realignments data resulted in no discernible difference in growth rates or parameter timings between the two characterizations within a BRAC round. The comparison of major versus minor facilities data also resulted in surprisingly similar parameter growth, despite the amount of minor facilities within a BRAC round being substantially less than that of major facilities. From these results, it appears the discussions of BRAC parametric effects can most effectively be constrained to a BRAC round as a whole unit, consisting of all facilities affected by the particular BRAC legislation. This supposition greatly enhances the envisioned broad applicability of the forecast model and provides for greater flexibility in implementing the relatively uncomplicated computational forecast model program.

E. SUMMARY

The effects of BRAC initiation on an installation are multi-faceted and repercussive. Of particular interest is the magnitude and timing of changes to environmental restoration parameters as a result of BRAC initiation. It is theorized that the initiation of a BRAC action has a profound effect on installation parameters, accelerating a facility's environmental restoration timetable and resulting in elevated expenditure rates and resource consumption.

The objective in fulfilling this research question is to determine the key installation parameters that appear sensitive to the initiation of BRAC. In an attempt to establish and quantify the effects of BRAC initiation on a facility's environmental parameters, the analysis of parametric change encompassed the full range of available DoN BRAC installation data for FY89 through FY96. The data were analyzed to determine what general effects are experienced by installation parameters after BRAC initiation, what is the timing of the noticeable parametric effects, and are the effects related uniquely to the type of BRAC action.

In addition to evaluating DoN BRAC facilities, three supplementary installation sets were established in order to provide comparative parameter trend baselines. The additional installation sets consisted of all DoN non-BRAC facilities that were on (or proposed to be on) the EPA's National Priorities List (NPL), Total DoN installation data measures (of which the BRAC and non-BRAC facilities are subsets), and Total DoD data measures (includes data from all the services and the Defense Logistics Agency).

The selection of the actual parameters compiled and analyzed centered largely on those variables that were determined to be significant restoration cost drivers during forecast model formulation. As was the case in forecast model formulation, the quality and quantity of data increased appreciably in the out years, especially in the FY94-FY96 period. As a result, much of the parametric trend analysis was hampered by poor quality or unavailability of installation data in the early years.

For the chosen variables to be analyzed, the parametric data were compiled for each installation set over the maximum amount of years figures were available. From the compilation of raw data, a yearly growth rate and a cumulative growth rate were calculated for each installation set in order to establish individual installation set trend lines. In general, the DoN BRAC installation set was compared to the other three sets to evaluate the parametric effects over time, if any, of BRAC proceedings. Not only was the DoN BRAC installation set evaluated as a whole, but data for BRAC rounds II, III, and IV were individually evaluated to ascertain any specific timing effects.

This chapter explored the quantifiable effects of BRAC initiation on installation variables. Several general parametric trends have become evident through the analysis of the installation data. The general trends are presented below as installation parameter "rules of thumb". The "rules of thumb" are to be utilized in incorporating the parametric effects precipitated by the conduct of BRAC proceedings into the forecast model. It is important to realize these general trends are rough approximations based on the analysis of limited data.

- The first full fiscal year after BRAC initiation is the most significant "Total Number of Sites (Sts(T))" parameter growth period for DoN BRAC installations. Additionally, DoN BRAC Sts(T) growth outpaced the Sts(T) growth of all other installation sets in each respective year following the BRAC initiations.

- DoN BRAC facilities averaged roughly 20% growth in Sts(T) in the first year following each BRAC initiation compared to only 14% growth for all other facilities.

- Overall DoN BRAC Sts(T) growth for the FY89-96 period averaged roughly 16% compared to roughly 13% for all other facilities over the same time period.

- The DoN BRAC installation set had the highest yearly growth rate for the "Sites with Cleanup Phase Complete or Underway (Sts(C))" parameter in both FY95 and FY96, most likely due to impending BRAC time requirements on cleanup.

- An initial spike in DoN BRAC cleanup activities, as measured by progress in the Sts(C) data, occurs in the third full year following each BRAC initiation.

- During the year when Sts(C) initial spikes occurred, DoN BRAC facilities more than doubled their number of Sts(C) from the previous year.

- DoN BRAC "Unsuitable Acreage (UnstA)" tended to decrease by roughly 10% per year in FY95-FY96 (based on the limited data available for calculating UnstA).

- The "average" time to complete a DoN BRAC Re-Use plan was roughly 2.5 years.

- Conservatively, a three year estimate for the inclusion of the R/U explanatory variable in the forecast model following a BRAC initiation is the most reliable trend prediction.

- The analysis of BRAC effects on the "Federal Facilities Agreement (FFA)" variable produced no reliable guidelines. The FFA variable, however, is a pivotal element of the forecast model. For this reason, each facility must be evaluated on an individual basis to determine the inclusion and timing of the FFA variable in the forecast model.

- The comparison of closures versus realignments and major versus minor facilities resulted in strikingly similar parameter growth. As a result, parametric guidelines are equally attributable for any type of BRAC action on any facility size.

The application of the parameter deltas to current/previous installation parameters will result in revised "expected" installation parameters. As detailed in Chapter VI, the revised parameter values can then be entered into the developed forecast model to predict costs associated with the effects of BRAC actions. The results of this chapter were generated through a painstaking and frustrating data collection process that merits and requires more in-depth installation-by-installation analysis to become a more reliable input to the cost estimation process.

VI. FORECAST MODEL IMPLEMENTATION & VALIDATION

A. BACKGROUND

Preceding chapters have established an extensive and solid foundation from which to analyze Base Realignment and Closure (BRAC) environmental restoration activities. Detailed presentations included explanations of influential BRAC activities and procedures, the development of an environmental restoration cost forecast model, and the quantification of installation parametric effects brought about by the initiation of BRAC action. The purpose of this chapter is to incorporate all the previously developed concepts in a credible and usable fashion. To meet the objectives, the chapter is arranged into three main sections:

- A spreadsheet-based implementation procedure for the developed forecast model
- A predictive strength validation analysis for the developed forecast model
- An approach to using forecast model methodology for broader DoD applications

B. FORECAST MODEL IMPLEMENTATION PROCEDURE

The function of this section is to present a usable methodology for the implementation of the developed forecast model. The presentation utilizes a columnar, "spreadsheet" format for the data entry of installation parameters and the calculation of forecast values from the generated regression equation. The structure of the spreadsheet and the required calculations are relatively simple and can be easily adapted to any spreadsheet program such as Microsoft's Excel™, Lotus' 1-2-3™, or Novell's Quattro© Pro™.

The basic template for effectively administering the developed forecast model is displayed in Table 6-1 below. The letter symbols refer to spreadsheet columns and the numeric symbols refer to spreadsheet rows. The required actions necessary to fill in the spreadsheet blocks are detailed in the subsections that follow.

	A	B	C	D	E	F	G	H	I	J
1	Instltn	Sts(T)	Sts(C)	UnstA	CA?	NPL	FFA	R/U	logt($TC)	Model Est.
2	(input)	(input)	(input)	(input)	(input)	(input)	(input)	(input)	(formula)	(formula)
3										

Table 6-1. Spreadsheet Template for Implementing the Developed Forecast Model

1. Installation Parameters

Since the developed forecast model is a predictive instrument of future expenditures, several parametric extrapolations or estimates are required. The best case scenario would include reliable parameter estimates from an installation's resident BRAC Environmental Coordinator (BEC). In theory, the estimates supplied by the BEC would be the most representative of future expected restoration activities.

In the absence of such estimates, the current year's installation data needs to be estimated through an extrapolation process employing the parametric "rules-of-thumb" developed in Chapter V. For example, Chapter V analysis shows that the DoN BRAC Sts(T) installation parameter increases by roughly 16% in a year. This empirically determined yearly growth rate would be applied to the current year's Sts(T) figure to estimate the next year's

Sts(T) spreadsheet input value. The same type of estimation approach can be applied to all current installation parameters via the guidelines expressed in Chapter V. Subsection B.4. that follows illustrates a functional example of installation parameter estimation.

2. The "logt($TC)" Calculation

The "logt($TC)" column uses the inputted parameter estimates in the preceding spreadsheet columns to calculate a logt($TC) value. The logt($TC) calculation is based on the explanatory variable coefficients derived in forecast model regression analysis. Each coefficient value is applied to its respective column parameter and then summed to form the logt($TC) value. For example, using the developed forecast model coefficient values provided by the DoN BRAC regression, the equation to be entered in cell "I2" of the spreadsheet (see Table 6-1) for parametric data in row 2 is given below.

The specific variable coefficient values are a generated output of the regression process as shown in Appendix B (i.e., "3.39748" is the regression constant; "0.014169" is the partial regression coefficient for the Sts(T) parameter; "0.03877"is the partial regression coefficient for the UnstA parameter; etc.). In addition, The cell term "B2" refers to column B / row 2; the cell term "C2" refers to column C / row 2; etc. The equation for parametric data in subsequent rows of the spreadsheet would be identical to the below equation with the exception of the column/row suffix. For instance, parametric data in row 3 would have the suffix of "3" vice "2" for each column reference (i.e., " = ...+0.014169*B3+0.03877*C3+..").

" = 3.39748+0.014169*B2+0.03877*C2+0.00011578*D2+0.31660*E2+
0.4293*F2+(-0.4597)*G2+0.26135*H2 " <enter>

3. The "Model Estimate (Est.)" Calculation

The "Model Est." column represents the principal output of the forecast model. To calculate and interpret this value properly, it is essential to recall from Chapter IV that a dependent variable transformation was required in order to correct an asymmetric $TC distribution. In rectifying this asymmetry, a logarithmic ("logt") transformation of $TC proved the most effective data distribution adjustment. The resultant $TC transformation manifests itself in both the outputted regression variable coefficients and the calculated logt($TC) value. Translating logt($TC) into proper budgetary figures requires a simple re-transformation of the calculated "logt($TC)" value, yielding a Cumulative Total Restoration Cost ($000) value. To accomplish this task, the below equation would be enter in cell "J2" of the spreadsheet for parametric data in row 2 (see Table 6-1). Similar to the discussion in the previous subsection, the equation for parametric data in subsequent rows of the spreadsheet would be identical to the below equation with the exception of the column/row suffix. For instance, parametric data in row 3 would have the suffix of "3" vice "2" for each column reference (i.e., " = 10 ^ I3 ").

" = 10 ^ I2 " <enter>

4. A Working Illustration

In order to demonstrate the forecast model spreadsheet implementation process, an illustrative example from a DoN BRAC installation is offered. The DoN BRAC installation to be estimated is Naval Air Station (NAS) South Weymouth. For purposes of this particular example, FY98 Cumulative Total Restoration Cost ($TC) will be forecasted from current (FY96) data. NAS South Weymouth's FY96 installation data is shown in Table 6.2 below.

Installation	BRAC	Sts(T)	Sts(C)	UnstA	CA?	NPL	FFA	R/U
NAS South Weymouth	IV	12	2	1192	0	1	0	0

Table 6-2. Spreadsheet Implementation Example - FY96 Installation Data

In this example we will rely solely on the empirically determined parametric effects guidelines, assuming the absence of better quality installation-specific estimates. Applying the relevant DoN BRAC effects parametric "rules-of-thumb" of Chapter V, NAS South Weymouth's FY96 installation data will be estimated for FY98 as follows:

- "Total Number of Sites (Sts(T))" data should grow by roughly 16% per year for a cumulative FY98 total of 16.
  - ➔ *FY96 data*: 12
  - ➔ *FY97 data*: 12+12*(.16) = 13.92
  - ➔ *FY98 data*: 13.92+13.92*(.16) = 16.14

- "Sites with Cleanup Phase Complete or Underway (Sts(C))" data should experience a near peak value in FY98 due its three year maturity within the BRAC process. Applying the third year "doubling" Sts(C) thumb rule, the Sts(C) value should increase from 2 in FY96 to approximately 4 in FY98.

- Unsuitable Acreage (UnstA) may be roughly estimated to decrease by 10% per year, although this parameter tends to be more erratic and installation-specific than other variables. Applying the yearly 10% reduction, the FY98 UnstA value is roughly 965.
  - ➔ *FY96 data*: 1192
  - ➔ *FY97 data*: 1192-1192*(.10) = 1073
  - ➔ *FY98 data*: 1073-1073*(.10) = 965.5

- As discussed in Chapter V, the analysis of BRAC effects on the "Federal Facilities Agreement (FFA)" variable produced no reliable general guidelines, therefore FFA estimation relies on individual installation data. In NAS South Weymouth's case, a specific review was required and revealed an "on-going" FFA negotiation in FY96. As a result, it is likely an FFA will be in place by FY98 and the FFA parameter will change state (i.e., from a "0" to a "1").

- The Re-Use Status (R/U) parameter will likely change state (i.e., from a "0" to a "1") based on the "passage of time (three years) since BRAC initiation" rule-of-thumb.

- The CA? and NPL variables are strictly installation-specific and are therefore, assumed to have not changed status.

Summarizing all of the "thumb rule" applications, NAS South Weymouth's FY98 installation parameter estimates for forecasting purposes are outlined in Table 6-3. Included in the table are a calculated logt($TC) value and a $TC ($000) model estimate.

	A	B	C	D	E	F	G	H	I	J
1	Instltn	Sts(T)	Sts(C)	UnstA	CA?	NPL	FFA	R/U	logt($TC)	Model Est.
2	So.Wymth	16	4	965	0	1	1	1	4.1192	$13,158

Table 6-3. Spreadsheet Implementation Example - FY98 Installation Forecast

The estimated Total Restoration Cost ($TC) forecasted with the developed model ("Model Est.") is $13,158,000 in FY98, representing a 103% increase over FY96's actual $TC of $6,469,000. As a means of comparative reference, DoN's FY98 $TC planning estimate for NAS South Weymouth is $14,754,000.

C. FORECAST MODEL VALIDATION

In order to confirm the functionality of the developed forecast model for DoN BRAC installations, comparative analyses of estimates versus actual costs were undertaken. Both the developed forecast model estimates and DoN's planning estimates were compared against actual costs to determine prediction variances. Analysis results are shown in Table 6-4 below.

Data Year	Average % Variance- (from "Actual" costs)	Developed Forecast Model Estimate	DoN Planning Estimate
FY96	"Additive"	+ 3.67 %	+ 9.43 %
	"Absolute Value"	22.62 %	36.79 %
FY95	"Additive"	- 4.94 %	- 16.94 %
	"Absolute Value"	33.97 %	42.34 %

Table 6-4. Comparative Predicted Cost Variance Analysis - DoN Data

Expenditure data from all 17 installations utilized in forecast model development were employed in the comparative analysis. Actual FY95 and FY96 environmental restoration cost data came from the respective year's DERP Annual Report to Congress. Similarly, the cost data for "DoN's Planning Estimate" also came from DERP reports. The "Forecast Model Estimate" values were calculated from individual installation parameters utilizing the prediction equation generated in forecast model development (as described in Chapter IV). Appendix C displays the DoN installation data evaluated in the cost variance analysis.

As shown in Table 6-4, there are two prediction variance characterizations calculated and presented in the comparative analysis. The "Average % Variance - Additive" category is derived from taking a cumulative sum of each installation cost variance percentage and then dividing the sum by the number of installations (17, in this case). The "Average % Variance - Absolute Value" category is derived from taking the cumulative sum of each installation cost variance *absolute value* percentage and then dividing the sum by the number of installations. The difference between the two variance categories lies in the treatment of cost variance percentages, as explained below.

For both DoN and the developed forecast model, prediction values versus actual costs deviated across the variance spectrum from underestimating to overestimating. For the purposes of this comparative analysis, a negative (-) cost variance percentage indicates an underestimation of predicted versus actual cost and a positive (+) cost variance percentage indicates an overestimation of predicted versus actual cost. In the "additive" variance calculation all installation underestimations (negative variances) and overestimations (positive variances) were algebraically summed to give a total variance percentage.

The relevance of the "additive" category lies in its direct applicability to BRAC environmental restoration budgeting. On a macro level, the "additive" category presents the overall dollar amount variance (in percent) between aggregate budgeted costs versus aggregate actual costs. The overall "additive" variance, therefore, gives a broad measure of performance relative to the adequacy of prior planning (i.e., the estimation of future restoration work and the budgeting for that work).

The "additive" category, however, is not without its analytical limitations. In theory, a prediction mechanism could wildly underestimate and overestimate costs in such a fashion as to have the algebraic sum (as employed in the "additive" case) result in zero variance. To avoid such misrepresentation, the absolute value cost variance percentages were calculated. The "absolute value" category simply treats all cost variances the same, regardless of underestimation or overestimation. Consequently, the "absolute value" variance analysis may be more suited for environmental restoration budgeting at each individual installation. As shown in Table 6-4 above, the developed forecast model estimates appear to outperform the DoN planning estimates under both the "Additive" and "Absolute Value" cost variance categories.

In an effort to further confirm the developed forecast model as a legitimate cost estimating tool, various additional statistical measures were taken on the restoration cost variance data. Cost variance data for both the developed forecast model and DoN's planning estimates were compared to show the relative strength of one versus the other. The results of the statistical measures are presented in Table 6-5 (FY96) and Table 6-6 (FY95). Akin to the "Additive" and "Absolute Value" cost variance comparisons, the developed forecast model generally outperformed the DoN planning estimates under these statistical measures.

Data Year	**Statistical Measure**	**Forecast Model Estimate**	**DoN Planning Estimate**
FY96	Median Variance Value	23.04 %	25.36 %
	# within 10% Variance	29.41 %	11.76 %
	# within 25% Variance	64.71 %	47.06 %
	# within 50% Variance	88.24 %	88.24 %
	Worst Overestimation	+ 52.40 %	+ 162.39 %
	Worst Underestimation	- 59.45 %	- 45.79 %

Table 6-5. Additional Predicted Cost Variance Statistical Measures for FY96

Data Year	Statistical Measure	Forecast Model Estimate	DoN Planning Estimate
FY95	Median Variance Value	30.94 %	43.72 %
	# within 10% Variance	11.77 %	29.41 %
	# within 25% Variance	29.41 %	35.29 %
	# within 50% Variance	88.24 %	52.94 %
	Worst Overestimation	+ 79.71 %	+ 84.56 %
	Worst Underestimation	- 77.45 %	- 84.34 %

Table 6-6. Additional Predicted Cost Variance Statistical Measures for FY95

D. APPLYING FORECAST MODEL METHODOLOGY

To test the broader applicability of the forecast model development methodology, certain Department of the Army ("Army") and Department of the Air Force ("Air Force") installation data were compiled, regressed, and formulated into service-specific forecast models. The assembled data consisted of those installation parameters determined to be statistically significant through the developed DoN regression process. The same installation criteria as employed in developing the DoN BRAC forecast model were also adopted for the Army and Air Force installations. Specifically, each eligible installation must be a BRAC I, II or III facilities with the required data available over the entire FY94-FY96 period. The Army installation set contained 17 facilities and the Air Force installation set contained 18 facilities.

Once the required installation data (i.e., Sts(T); Sts(C); UnstA; CA?; NPL; FFA; R/U) were gathered, each service's parameters underwent the same multiple regression procedure against the logarithmically transformed values of $TC as employed in developing the DoN forecast model. The resultant explanatory variable regression coefficients were then utilized to develop each service's model estimate equations to be entered in the spreadsheet forecast format. Finally, a comparative analysis of the model estimates and each service's planning estimates versus actual costs was conducted in the same fashion as previously described in Section C for the DoN model. The results of the comparative analyses are shown in Tables 6-7 (Army) and 6-8 (Air Force) below.

Data Year	**Average % Variance- (from "Actual" costs)**	**Army Forecast Model Estimate**	**Army Planning Estimate**
FY96	"Additive"	- 4.20 %	- 16.19 %
	"Absolute Value"	61.22 %	32.32 %
FY95	"Additive"	+ 8.47 %	- 9.14 %
	"Absolute Value"	49.62 %	31.61 %

Table 6-7. Comparative Predicted Cost Variance Analysis - Army Data

Data Year	**Average % Variance- (from "Actual" costs)**	**Air Force Forecast Model Estimate**	**Air Force Planning Estimate**
FY96	"Additive"	+ 2.01 %	+ 44.12 %
	"Absolute Value"	41.40 %	44.12 %
FY95	"Additive"	+ 14.39 %	+ 61.58 %
	"Absolute Value"	43.18 %	61.58 %

Table 6-8. Comparative Predicted Cost Variance Analysis - Air Force Data

The interpretation of the "Average % Variance" categories for Tables 6-7 and 6-8 is the same as that described for DoN data following Table 6-4 in Section C. Table 6-7 (Army) reveals that, despite the relative success of derived Army forecast model in the "additive" variance category, Army planning estimates appear to be more reliable predictors than the derived model. Recall that the "additive" variance prediction mechanism is susceptible to wildly underestimated and overestimated cost estimates having their algebraic sum (as employed in the "additive" case) result in zero variance. The analytical limitation of the "additive" variance measures seems to be relevant in this case since the derived forecast model's estimate of Army data shows significantly high "absolute value" variance with relatively low "additive" variance. Contrarily, the Army planning estimates show consistently low cost variance percentages over both variance measures and are comparable to those seen for the developed DoN forecast model on Navy data, suggesting strength in current Army estimation practices.

Analyzing Table 6-8 (Air Force) variance data reveals that neither the derived Air Force forecast model nor Air Force planning estimates serve as reliable cost predictors. In fact, Air Force planning estimates overestimated actual cost in every instance.

It is readily apparent that the envisioned broad applicability of the developed DoN forecast model cost factors and estimation methodology may not have fully materialized. Each service's derived forecast model cost variances (especially, "absolute value" variances) were of significant magnitude to warrant concern as to the reliability of the estimation. The derived forecast model estimates were not nearly as accurate as the DoN developed forecast model proved to be for DoN facility estimates.

In an attempt to account for the apparent lack of true model applicability, several observations are offered below for the experienced large non-DoN forecast model estimates variances of the other services. An obvious distinction between the service installations is their past operational history and functions. The previous activities at a facility directly contribute to the type and disposition of contamination which, in turn, drives the extent of environmental restoration efforts. It may be that the significant cost drivers uncovered during the exhaustive DoN forecast model development are not the same cost drivers for the other service facilities. Some general operating differences may serve as examples of the varied restoration actions required that are dependent on past operations and facility usage. For instance, a meaningful percentage of the Army installations under study had significant ordnance-related restoration efforts not seen in the Navy or Air Force data. Additionally, due to relatively larger land sizes, the Air Force data had inflated (as compared to Navy data) site totals and acreage figures not commensurate with inflated total restoration costs. Perhaps then, the unique nature of each service's installations and their equally unique environmental restoration requirements demand the exhaustive and iterative development of service-specific regression formulas and forecast models.

E. SUMMARY

The results of research and forecast model formulation provide an extensive and practical foundation from which to analyze BRAC environmental restoration activities. A usable methodology for the implementation of the developed DoN forecast model, incorporating many of the key developed concepts, serves as the culminating product of the research effort. The implementation procedure presentation utilizes a columnar "spreadsheet" format for the inputting of installation parameters and the calculation of forecast values from the generated regression equation. The structure of the spreadsheet and the required calculations are relatively simple and can be easily adapted to any spreadsheet program.

Utilizing the forecast model implementation procedure, the developed DoN forecast model was employed in a comparative analysis to establish its validity and credibility. The results of FY95 and FY96 cost estimate comparisons for Navy installation data provided solid substantiation that the developed forecast model is an accurate estimation tool. In fact, the developed forecast model outperformed DoN's planning estimates for the facilities under study in the FY95 and FY96 time period. However, despite the relative success of the developed forecast model as compared to DoN planning estimates, the cost variance percentages are of a considerable enough magnitude to suggest still a better cost prediction system is required. Perhaps, there is some value to be gained in more detailed comparisons of the developed forecast model and the current systems used in deriving planning estimates. The comparisons may uncover significant similarities and/or gross differences that would point the way to vital environmental restoration factors to be further scrutinized.

Regrettably, the envisioned broad applicability of the developed DoN forecast model does not appear to extend beyond its employment to DoN facilities. It is clear from the results of employing Army and Air Force data into the previously developed structure that the statistically significant cost drivers established through the exhaustive regression process for DoN data do not necessarily hold true for the other services.

Each of the other service's installations appear to have unique attributes and operational histories that make the application of the DoN-specific developed forecast model incompatible with another service's parametric data. An obvious distinction between the service installations is their past operational history and functions. The previous activities at a facility directly contribute to the type and disposition of contamination which, in turn, drives the extent of environmental restoration efforts.

Some general operating differences may serve as examples for the myriad of required restoration actions required are dependent on past operations and facility usage. For instance, a meaningful percentage of the Army installations under study had significant ordnance-related restoration efforts not seen in the Navy or Air Force data. Additionally, due to relatively larger land sizes, the Air Force data had inflated (as compared to Navy data) site totals and acreage figures not commensurate with inflated total restoration costs. Perhaps then, the unique nature of each service's installations and their equally unique environmental restoration requirements demand the exhaustive and iterative development of service-specific regression formulas and forecast models.

It is important to remember, however, the strength of the developed DoN forecast model when applied to Navy data. To parlay the successful DoN implementation, it is recommended that Army and Air Force data undergo a similar all-inclusive, iterative installation parameter regression process to ascertain the service-specific statistically significant cost drivers. Once the entire regression process is employed and each service's key installation parameters are determined, the forecast implementation method should be identical to that described for DoN data.

VII. SUMMARY & CONCLUSIONS

A. INTRODUCTION

The results of thesis research on environmental restoration activities and expenditure modeling have proven to be both insightful and thought-provoking. Every aspect of DoD's environmental restoration activities warrants in-depth evaluation. The examination of specific DoN environmental restoration programs related to Base Realignment and Closure (BRAC) actions, however, facilitated a more focused and conquerable undertaking. Research efforts for the project ranged broadly from various program organizations and functions to the validation of an empirically derived restoration expenditure forecast model. As with any study of a varied and complex system such as environmental restoration, some areas of research raised as many questions as were answered.

The remainder of the chapter is broken down into three sections. Section B provides a succinct summarization of the research project, reviewing the major points for each area of concentration. Section C highlights the project's major research findings. Section D presents recommendations for further research and forecast model extension.

B. RESEARCH SUMMARY

Presented in the subsections that follow is an abbreviated recapitulation of the principal research areas and themes. The summary is intended to highlight the critical issues germane to the operation of DoN's BRAC environmental restoration program.

1. BRAC and Environmental Restoration

The U.S. military has faced imposing force structure reductions during the last decade. Spurred by the termination of the Cold War and persistent fiscal pressures, military force structure and National Security budget authority have decreased 40% in the last ten years. Complementing the force structure reductions, though lagging in both extent and duration, four rounds of Base Realignment and Closure (BRAC) have been authorized to reduce surplus infrastructure. Reducing and realigning base structure allows DoD to avert substantial long-term operational costs by eliminating excess capacity.

As the BRAC process unfolds, environmental cost issues are being placed under ever increasing scrutiny by civilian communities, government agencies, and the Congress. Military environmental restoration costs have risen sharply (and far above expectations) in recent years, with the unanticipated cost growth occurring most visibly for bases on the BRAC lists. Specifically, BRAC annual environmental funding for military departments has grown nearly threefold from FY91 to FY96, approaching one billion dollars annually. Among the chief concerns surrounding BRAC environmental activities are the forecasting of accurate cleanup costs, the timing of appropriations coincident with cleanup needs, and the prioritization of available cleanup funds.

At the heart of the debate is a long-standing DoD policy that excludes environmental restoration costs as a factor in the BRAC decision process. Environmental restoration costs are not included in DoD's net present value analysis. Conventional wisdom contends that restoration expenditures are "sunk costs" since public law requires military bases to meet environmental standards regardless of operating status. What is absent from this contention is the accelerated timetable and increased rate of resource consumption necessary to meet BRAC timeline requirements and reap prompt BRAC savings. In fact, the alternatives DoD foregoes in redirecting limited funding to accelerate environmental restoration have tangible value (i.e., opportunity cost) that deserves to be acknowledged as part of a BRAC decision.

2. The Defense Environmental Restoration Program

The principal component of the military's environmental restoration efforts is the Defense Environmental Restoration Program (DERP). The DERP provides organizational and operational systems crucial to program policy, execution, and oversight. Each service component further delineates DERP procedures, management, and implementation through its respective chains of command for day-to-day operations. For DoN, the environmental restoration implementation responsibilities rest with the Naval Facilities Engineering Command (NAVFACENGCOM). For research purposes, one of the most important of the many and varied functions of the DERP and NAVFACENGCOM is the classification and cataloging of environmental restoration activity data. In analyzing restoration activities, it is necessary to recognize functional differences among the categories and phases associated with environmental restoration. Each category and phase has certain requirements and procedures that uniquely steer its activities and, ultimately, its expenditures and expenditure rate.

In broad terms, there are two categories (with associated phases) related to restoration that are fundamental to this thesis research - Investigation activities and Cleanup activities. Generally, the phases of Investigation cover vast amounts of real estate, require substantial time to complete, and serve as groundwork for follow-on actions. The Cleanup phases, on the other hand, are characterized by concentrated and high cost end-product activities. Recent trends have suggested that the time consuming and sequential Investigation activities can be reduced in favor of accelerated and focused Cleanup actions.

The applicable legislative and regulatory requirements governing the DERP and BRAC processes unequivocally underpin program formation and initiatives. The most notable regulatory mandates (ordered by relative importance) include: the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA); the Superfund Amendments and Reauthorization Act of 1986 (SARA); The National Environmental Policy Act of 1970 (NEPA); and The Community Environmental Response Facilitation Act of 1992 (CERFA). CERCLA and its amendment, SARA, formed the basis for the DERP Installation Restoration Program (IRP) process and their mandates created much of the existing structure. NEPA requirements drive many of the program operations and initiatives to satisfy its evaluation and reporting commitments. CERFA is the most recent major legislation affecting BRAC and is responsible for DoD's parcelization efforts.

Program initiatives are generally the results of legislative and regulatory compliance in a dynamic political and budgetary situation. Examining DERP initiatives reveal trends in program composition and operation, ultimately unveiling the environmental restoration cost drivers. The sweeping drive to accelerate remediation actions over investigation actions notwithstanding, several initiatives dominate the program. The Fast Track Cleanup initiative comprises the vast majority of BRAC environmental restoration undertakings. Additionally, the recent Relative Risk Reduction Program initiative provides a framework for prioritizing work, measuring performance, and justifying requirements and funding.

3. Environmental Restoration Program Funding

To fund DoD's environmental restoration efforts, Congress provides funds in two separate accounts - The Defense Environmental Restoration Account (DERA) and the environmental subaccount of the Base Closure Account (BCA). The DERA primarily incorporates operating installations while the BCA subaccount incorporates closing and realigning installations. Although their utilization is strictly segregated by statute, the two accounts are organizationally linked. In fact, all of the DoN BRAC installations utilized in the forecast model formulation of this thesis consumed DERA funds prior to being placed on their respective BRAC lists.

The BCA furnishes the greatest flexibility in meeting unique and stringent regulatory and requirements timeline restrictions for BRAC facilities. Funding for DoD's BRAC environmental restoration comes from one of six BCA subaccounts appropriated by Congress. The BCA environmental subaccount is executed by NAVFACENGCOM under the DERP in similar fashion to DERA appropriations. The BCA funds are provided in flexible five year accounts and the subaccounts are not fenced. There is, however, a statutory ceiling for the BCA's environmental subaccount to limit expenditures for restoration.

In the last 12 years, nearly $4 billion in environmental restoration funding (DERA and BCA) was spent identifying, assessing, and cleaning up past hazardous waste disposal sites at both active and BRAC Navy and Marine Corps installations. A significant segment of the early DoN DERA funding, especially in the investigation category, was expensed on sites at installations subsequently affected by the four rounds of BRAC. The BRAC funds, in the form of the BCA environmental subaccount, have been expended by DoN to exclusively fulfill the environmental requirements for the 1,035 BRAC sites on Navy controlled property. The bulk of recent DoN BCA environmental funds has supported the cleanup category of the restoration program, increasing expenditures in cleanup phases by roughly six times in the last few years. DoN's ability to concentrate BRAC environmental monies on genuine remediation is due in large part to both DoD's "cleanup versus investigation" initiative and the previous expenditures of DERA funds on the site investigation phases.

4. Environmental Restoration Expenditure Forecasting

The fundamental complexity and multiple attributes of environmental cleanup create significant challenges to effective budgeting. Assorted regulatory requirements and the uniqueness of individual installations further complicate restoration efforts and proper budgetary forecasting. Adding to the predicament, the military departments are accelerating environmental cleanup actions in order to expedite suitable property transfer or reuse. Without accurate cost forecasting to complement the needed acceleration initiatives, the necessary fiscal resources will not be available to foster prompt property turnover and realize timely savings. In today's austere budgetary environment, a reliable expenditure forecasting model is essential to accurately demonstrate the resource requirements necessary to complete suitable environmental restoration and subsequent transfer/reuse of BRAC lands.

To achieve the primary thesis objective of constructing a comprehensive, inclusive, and functional environmental restoration cost forecasting model, substantial amounts of installation data required rigorous analysis and configuration. To this end, over 25 separate installation statistical parameters were compiled for each of the qualifying 17 DoN BRAC facilities over the most recently available three year period (FY94-FY96). A multiple regression technique was employed to manage the extensive data and construct the forecast model. Multiple regression is a multifaceted estimating method, quantifying relationships and causality among multiple variables in the analysis of empirical data.

C. MAJOR RESEARCH FINDINGS

In the process of thesis research and expenditure modeling, several decisive aspects of the environmental restoration process have come to light. This section is an extension of the research summarization of the previous section and provides a synopsis of the major findings established during the research process. The displayed order of the subsection major finding descriptions is chronological in relation to the thesis presentation and is not intended to suggest relative importance or significance.

1. A Tenable and Practical Forecast Model

In creating a realistic and reliable forecast model, the objective was to construct a multiple regression model relating environmental restoration costs to several decisive explanatory variables. Since there is no certifiable link between environmental restoration costs and any exclusive set of installation variables, the regression model approach was necessarily an empirical endeavor. To assure complete and conclusive results, an exhaustive set of explanatory variable candidates likely to influence environmental restoration costs was assembled to systematically construct the forecast model and to test its adequacy of fit.

The model formulation strategy consisted of regressing each of the dependent variable candidates - Total Cost ($TC); Investigation Cost ($IC); and Cleanup Cost ($CC) - on *all* the explanatory variable candidates. Total variable inclusion ensured no fundamental causal variables were omitted from the model. This method permitted examination of the individual partial regression coefficients in order to make judgements about the importance of each explanatory variable and permitted statistical comparison of successive regression revisions.

From the all-encompassing initial regression models, systematic statistical reduction continued, one explanatory variable at a time, until all remaining variables were statistically significant. Parallel to this statistical analysis, each successive regression was evaluated on its performance in improving overall model significance. Assessments were based on comparing F-statistics, Coefficients of Determination (R-Sq), and Standard Error of Estimates (S) in each ensuing regression run.

Each dependent variable underwent the comprehensive regression model formulation process to ensure all plausible combinations of installation data were incorporated. The best combination of explanatory variables for each of the dependent variables and, thus the most significant forecasting model, proved to be the regression of the Total Cumulative Environmental Restoration Cost (Total Cost ($TC)) dependent variable.

The resultant $TC regression output is the most preferred combination of highest F-Statistic, highest R-Sq, and lowest Standard Error of Estimate (S). Deserving of particular mention is the remarkably substantial value for the Coefficient of Determination (R-Sq), given the purely empirical nature of the regression data. The resultant R-Sq value implies that 75% of the variation in Total Cost ($TC) is explained by the assembled dependent variables.

2. Significant Environmental Restoration Cost Drivers

Of the 25 explanatory candidates included in the initial Total Restoration Cost ($TC) regression model runs, only seven installation variables proved statistically significant for forecasting purposes. The final set of seven explanatory variables contained three quantitative variables - Total Sites (Sts(T)); Sites with Cleanup Phase complete or underway (Sts(C)); Unsuitable Acreage (UnstA) - and four qualitative variables - Installation State (CA?); NPL Status (NPL); FFA Status (FFA); Re-Use Plan Status (R/U)).

Further comparison of results for each of the three different dependent variable regressions highlighted the common cost drivers present in every model. Four explanatory variables - Total Sites (Sts(T)); Sites with Cleanup Phase complete or underway (Sts(C)); Installation NPL Status (NPL); and Re-Use Plan Status (R/U)) - were significant factors in each dependent variable regression, suggesting that these four installation parameters are the most universally applicable cost drivers for any type of environmental restoration cost being estimated. In comparing the less volatile Investigation Cost and Total Cost regressions, all seven explanatory variables listed in the preceding paragraph were statistically significant in both cases. Of note, the Installation Type (TYPE) explanatory variable was only slightly below the statistical critical value in both the Total Cost and Investigation Cost regressions.

3. Statistical Insignificance of Relative Risk Program Data

In an attempt to facilitate inclusion of Relative Risk Site Evaluation parameters, additional regressions were performed on each dependent cost variable. DoD's Relative Risk Site Evaluation framework is intended to adjust environmental restoration goals based on a site prioritization basis. Reduced funding levels command DoD to more effectively direct its limited resources to sites that pose the greatest threat to human health and the environment. The Relative Risk strategy assigns each potentially contaminated site to a high, medium, or low risk category. In determining the categorization, the Relative Risk procedure addresses several site characteristics, including: specific contaminants present; the significance of contamination; contaminant migration pathways; and human and ecological receptors located near the site.

Due to the recent implementation of the Relative Risk program, the regressions including Relative Risk data utilized only FY95 and FY96 data. Employing the identical formulation process used to build the more inclusive FY94-FY96 model, each dependent variable underwent a similar comprehensive regression procedure to ensure all plausible combinations of installation data were incorporated. Each regression's statistical results for FY95-96 data were encouragingly similar to the results of the full data (FY94-FY96) regression statistical outcomes. As in the full data regressions, the most statistically significant results proved to be the regressions on Total Cost ($TC).

Although the FY95-FY96 regression results go a long way in supporting the robustness of the full FY94-FY96 data regression model, an additional major research finding is the real success of the FY95-FY96 data test. In each of the regressions on the dependent variables, all of the models produced results *devoid* of the high priority Relative Risk parameters - High Priority Sites (Sts(H)) and Medium Priority Sites (Sts(M)) - as statistically significant explanatory variables. In fact, the Relative Risk data were not even marginally significant in any of the iterative regressions.

The statistical insignificance of the Relative Risk data in forecast model formulation may be interpreted in two general ways:

- The cost effects of the Relative Risk measures are already captured by some of the variables resident in the developed forecast model and thus, the Relative Risk measures become redundant and insignificant variables.
- The Relative Risk program may not be properly constructed due to being an *a priori* measure based on supposition rather than an empirically based measure.

When analyzing the Relative Risk program and the developed forecast model it seems that Relative Risk characterization procedures (described previously) include assessments on installation parameters *not* captured by the developed forecast model variables. As a result, the second interpretation of Relative Risk insignificance (see above) appears more accurate. However, with the recent (FY95) implementation of Relative Risk Site Evaluation, the use of only the first two years of program data may not be indicative of the future significance Relative Risk plays in driving environmental restoration costs. Further research should focus on the Relative Risk Site Evaluation initiative to ensure it is meeting its intended purpose.

4. Parametric Effects Resulting from BRAC Initiation

The effects of BRAC initiation on an installation are multifaceted and expansive. All aspects of the affected facility are thrust into a state of dynamic transformation. Of particular interest is the magnitude and timing of changes to environmental restoration parameters as a result of BRAC initiation. It is theorized that the initiation of a BRAC action has a profound effect on installation parameters, accelerating a facility's environmental restoration timetable and resulting in elevated expenditure rates and resource consumption.

In an attempt to establish and quantify the effects of BRAC initiation on a facility's environmental parameters, an analysis of parametric change was conducted. Data included the full range of available DoN BRAC data (FY89 - FY96) and were analyzed to determine: the general effects experienced by installation parameters after BRAC initiation; the timing of the noticeable parametric effects; and the effects related uniquely to the type of BRAC action (i.e., major vs. minor; closure vs. realignment).

In addition to evaluating DoN BRAC facilities, three supplementary installation sets were established in order to provide comparative parameter trend baselines. The additional installation sets consisted of all DoN non-BRAC facilities that were on (or proposed to be on) the EPA's National Priorities List (NPL), Total DoN installation data measures (of which the BRAC and non-BRAC facilities are subsets), and Total DoD data measures (includes data from all the services and the Defense Logistics Agency).

From the compilation of raw data, a yearly growth rate and a cumulative growth rate were calculated for each installation set in order to establish individual installation set trend lines. In general, the DoN BRAC installation set was compared to the other three sets to evaluate the parametric effects over time, if any, of BRAC proceedings. Not only was the DoN BRAC installation set evaluated as a whole, but data for BRAC rounds II, III, and IV were individually evaluated to ascertain any specific timing effects.

Several general parametric trends have become evident through the analysis of the installation data. The general trends are presented on the following page as installation parameter "rules of thumb". The "rules of thumb" are to be utilized in incorporating the parametric effects precipitated by the conduct of BRAC proceedings into the forecast model.

- The first full fiscal year after BRAC initiation is the most significant "Total Number of Sites (Sts(T))" parameter growth period for DoN BRAC installations. Additionally, DoN BRAC Sts(T) growth outpaced the Sts(T) growth of all other installation sets in each respective year following the BRAC initiations.

- DoN BRAC facilities averaged roughly 20% growth in Sts(T) in the first year following each BRAC initiation compared to 14% growth for all other facilities.

- Overall DoN BRAC Sts(T) growth for the FY89-96 period averaged roughly 16% compared to roughly 13% for all other facilities over the same time period.

- The DoN BRAC installation set had the highest yearly growth rate for the "Sites with Cleanup Phase Complete or Underway (Sts(C))" parameter in both FY95 and FY96, most likely due to impending BRAC time requirements on cleanup.

- An initial spike in DoN BRAC cleanup activities, as measured by progress in the Sts(C) data, occurs in the third full year following each BRAC initiation.

- During the year when Sts(C) initial spikes occurred, DoN BRAC facilities more than doubled their number of Sts(C) from the previous year.

- DoN BRAC "Unsuitable Acreage (UnstA)" tended to decrease by roughly 10% per year in FY95-FY96 (based on the limited data available for calculating UnstA).

- The "average" time to complete a DoN BRAC Re-Use plan was roughly 2.5 years.

- The analysis of BRAC effects on the "Federal Facilities Agreement (FFA)" variable produced no reliable guidelines. The FFA variable, however, is a pivotal element of the forecast model. For this reason, each facility must be individually evaluated to determine the inclusion and timing of the FFA variable in the forecast model.

- The comparison of closures versus realignments and major versus minor facilities resulted in strikingly similar parameter growth. As a result, parametric guidelines are equally attributable for any type of BRAC action on any facility size.

The application of the parameter deltas to current/previous installation parameters will result in revised "expected" installation parameters. The revised parameter values can then be entered into the developed forecast model to predict costs associated with future initiation of base closure\realignment.

5. Validation of the Developed Forecast Model

The results of research and forecast model formulation provide an extensive and practical foundation from which to analyze BRAC environmental restoration activities. A usable methodology for implementing the developed forecast model, incorporating many of the key developed concepts, serves as the principal output of the research effort. The forecast model implementation procedure utilizes a columnar "spreadsheet" format for the data entry of installation parameters and the calculation of forecast values from the generated regression equation. The structure of the spreadsheet and the required calculations are relatively simple and can be easily adapted to any spreadsheet program.

Utilizing the implementation procedure, the developed DoN forecast model was employed in a comparative analysis to establish its validity and credibility. The results of FY95 and FY96 cost estimate comparisons for Navy installation data provided solid substantiation that the developed forecast model is an accurate estimation tool. The developed forecast model outperformed DoN's planning estimates over many statistical measures for the facilities under study in the FY95 and FY96 time period.

6. Applicability of the Developed Forecast Model

Regrettably, the envisioned broad applicability of the developed DoN forecast model does not appear to extend beyond its employment to DoN facilities. It is clear from the results of employing Army and Air Force data into the previously developed forecast model structure that the statistically significant cost drivers established through the exhaustive regression process for DoN data do not necessarily hold true for the other services.

Each of the other service's installations appear to have unique attributes and operational histories that make the application of the DoN-specific developed forecast model incompatible with another service's parametric data. An obvious distinction between the service installations is their past operational history and functions. The previous activities at a facility directly contribute to the type and disposition of contamination which, in turn, drives the extent of environmental restoration efforts.

Some general operating differences may serve as examples for the myriad of required restoration actions that are dependent on past operations and facility usage. For instance, a meaningful percentage of the Army installations under study had significant ordnance-related restoration efforts not seen in the Navy or Air Force data. Additionally, due to relatively larger land sizes, the Air Force data had inflated (as compared to Navy data) site totals and acreage figures not commensurate with inflated total restoration costs. Perhaps then, the unique nature of each service's installations and their equally unique environmental restoration requirements demands the exhaustive and iterative development of service-specific regression formulas and forecast models.

It is important to remember, however, the strength of the thesis-developed DoN forecast model when applied to Navy data. To emulate the successful DoN implementation, similar application of the DoN-proven all-inclusive, iterative installation parameter regression process technique to Army and Air Force data would be beneficial in ascertaining the service-specific statistically significant cost drivers. Once the entire regression process is employed and each service's key installation parameters are determined, the forecast implementation method should be identical to that described for DoN data.

D. RECOMMENDATIONS FOR FURTHER RESEARCH

Although research efforts have provided considerable insight into DoN's BRAC environmental restoration activities, there remains substantial areas for examination left unexplored. In the hopes of initiating further study on DoD's environmental restoration program, several recommendations for further research and forecast model extension are assembled below.

- Enhance the DoN forecast model developed in this thesis with the inclusion of more recent installation data as it becomes available. The additional data needs to be added to the all-inclusive installation parameter database to facilitate an expanded comprehensive iterative regression process and obtain the most accurate forecast model. The most recent data (FY97) should be available shortly after the release date of this project.

- Apply the DoN-proven technique of an all-inclusive iterative regression on BRAC data to the other services (i.e. Army and Air Force). Analysis demonstrated that each service appears to have unique restoration requirements based on their past operational histories. For this reason, each service must undergo individual comprehensive forecast model formulation to determine each service's significant environmental cost drivers.

- Compare and contrast the current environmental restoration cost estimating practices of the services. Data analysis revealed that current Army planning estimates appear to outperform current planning estimates of the other services when analyzing BRAC installation cost variances. An examination of each service's forecasting system will determine model commonality and facilitate the application of "best practice" across service lines.

- Apply the general developed forecast model methodology to DoD's Formerly Used Defense Sites (FUDS). FUDS are a logical extension of BRAC sites based on similarities in unique requirements, timeline constraints, and extensive reliance on cooperative agreements.

- Develop a broader environmental restoration cost forecast model based on extensive DoD installation data. Although the bulk of research focused on DoD's/DoN's BRAC restoration activities, the methodology employed in arriving at the developed forecast model is flexible enough to incorporate all types of variables and installations.

- Investigate the implementation of DoD's Relative Risk Evaluation Program. In each of the DoN regressions on the dependent cost variables, all of the models produced results *devoid* of the high priority Relative Risk parameters as statistically significant explanatory variables. In fact, the Relative Risk data were not even marginally significant in any of the iterative regressions. With the recent (FY95) implementation of the Relative Risk program, the utilization of only the first two years of program data may not be indicative of the future significance Relative Risk plays in driving environmental restoration costs. As a result, further research must focus on the Relative Risk Site Evaluation initiative to ensure it is meeting its intended purpose.

- Broaden the scope of environmental restoration research to include a detailed cost-benefit analysis of environmental restoration technology and outsourcing. Ultimately, long-term cost control will depend on successfully developing more efficient ways to remediate contaminants.

- Pursue the inclusion of reliable environmental restoration expenditure estimations into DoD's BRAC cost model - Cost of Base Realignment Actions (COBRA) model.

APPENDIX A. ENVIRONMENTAL RESTORATION INSTALLATION DATA

This appendix features the entirety of the parametric installation data utilized in forecast model formulation. Each data year (FY-94 through FY96) is separately tabulated with its corresponding dependent and explanatory variables. Data for all parameters were obtained chiefly from the DERP's Annual Reports to Congress for FY94 through FY96 and installation information provided by NAVFACENGCOM via their Site Base Cleanup Plan (BCP) Internet web pages.

FY96 DEPENDENT and EXPLANATORY VARIABLE INSTALLATION REGRESSION DATA

Installation	ST	Type	COST DATA ($000) $IC	$IA	$RD	$Rmd	$CC	$TC	SITES Ttl	RC	S-c	S-u	IA-c	IA-u	D-c	D-u	C-c	C-u	H	M	Excess Acrge	Instln Acrge	EnvSuit Acrge	Unsuit. Acrge	% Unst Acrge	YTC	YRCI	CA	NPL	FFA	R/U	EBS	OP?
Agana	GU	NAS	18667	0	0	0	0	18667	30	0	0	30	12	3	0	1	0	0	2	12	2435	2435	0	2435	100.00%	6	13	0	0	0	1	1	0
Alameda	CA	NAS	40955	10918	64	524	11506	52461	30	0	0	30	0	9	0	0	0	4	14	10	2634	2634	6	2628	99.77%	21	8	1	0	1	1	1	1
Barber's Pt.	HI	NAS	18195	0	0	68	68	18263	25	2	4	21	3	0	0	0	0	2	3	12	2542	3822	0	2542	100.00%	11	12	0	0	0	0	1	1
Cecil	FL	NAS	13468	2375	336	697	3408	16876	25	2	8	17	8	7	3	0	1	1	15	5	17607	31366	16257	1350	7.67%	7	12	0	1	1	1	1	1
Davisville	RI	NCBC	24188	314	1041	4384	5739	29927	25	10	13	12	10	2	9	4	5	2	3	4	1294	1294	518	776	59.97%	31	13	0	1	1	1	1	0
El Toro	CA	MCAS	31481	968	288	3041	4297	35778	43	0	8	35	1	4	0	1	0	8	20	5	4776	4855	3430	1346	28.18%	11	12	1	1	1	0	1	1
Glenview	IL	NAS	4413	50	338	6838	7226	11639	36	2	3	33	0	1	0	0	0	1	11	12	1207	1285	811	396	32.81%	7	9	0	1	1	1	1	0
Hunter's Pt.	CA	NSY	89156	14518	3128	7943	25589	114745	74	8	8	66	0	12	0	0	0	0	24	20	936	936	88	848	90.60%	14	9	1	1	1	1	1	0
Long Beach	CA	NSTA	22274	527	0	1729	2256	24530	9	0	2	7	0	2	0	0	0	2	4	3	1209	1497	361	848	70.14%	12	14	1	0	0	1	1	0
Mare Island	CA	NSY	29034	2793	37	2658	5488	34522	36	0	0	36	15	11	0	0	0	0	19	5	5646	5646	451	5195	92.01%	13	17	1	0	1	1	1	1
Moffett	CA	NAS	44741	2176	2030	9322	13528	58269	34	11	21	13	11	2	6	5	4	3	21	0	3097	3700	2514	583	18.82%	31	13	1	1	1	1	1	0
Orlando	FL	NTC	6892	1072	5	1	1078	7970	14	8	9	5	0	2	1	1	1	0	1	0	2034	2075	1514	520	25.57%	8	12	0	0	0	1	1	1
San Diego	CA	NTC	6483	85	242	250	577	7060	14	3	5	9	5	0	0	1	0	2	1	2	420	552	420	0	0.00%	9	11	1	0	0	0	1	1
Trs. Island	CA	NSTA	8713	214	42	10	266	8979	31	4	4	27	3	1	0	0	0	0	18	6	717	1080	78	639	89.12%	7	9	1	0	1	1	1	1
Trenton	NJ	NAWC	7307	717	15	505	1237	8544	11	2	2	9	4	2	2	1	2	1	2	0	54	54	21	33	61.11%	28	11	0	0	0	1	1	0
Tustin	CA	MCAS	4019	21690	26	6486	28202	32221	28	0	3	25	2	0	0	1	0	3	3	10	1383	1383	1301	82	5.93%	9	12	1	0	0	1	1	1
Warminster	PA	NAWC	5618	133	1048	4563	5744	11362	10	1	3	7	4	1	2	5	1	2	8	1	779	818	360	419	53.79%	31	17	0	1	1	1	1	1

CHART LEGEND

COST DATA

$IC	Total Cumulative Investigation Cost
$IA	Total Cumulative Interim Actions Cost
$RD	Total Cumulative Remedial Design Cost
$Rmd	Total Cumulative Remediation Cost
$CC	Total Cumulative Cleanup Category Cost ($CC = $IA + $RD + $Rmd)
$TC	Total Environmental Restoration Cost ($TC = $IC + $CC)

SITE DATA

Ttl	Total Number of Installation Sites
RC	Number of Sites w/Response Complete
S-c	Sites with Study Phase Complete
S-u	Sites with Study Phase Underway
IA-c	Number of Interim Actions Complete
IA-u	Number of Interim Actions Underway
D-c	Sites with Design Phase Complete
D-u	Sites with Design Phase Underway
C-c	Sites with Cleanup Phase Complete
C-u	Sites with Cleanup Phase Underway
H	Sites with Relative Risk - High
M	Sites with Relative Risk - Medium

ACREAGE & YEAR DATA

ExcessA	Excess Acreage
InstlnA	Installation Acreage
EnvStA	Environmentally Suitable Acreage
UnStA	Unsuitable Acreage
%UnStA	% Unsuitable Acreage
YTC	Estimated Years-to-Complete
YRCI	Years Restoration Costs Incurred (number of years since first Restoration Costs were incurred)

CATEGORICAL

CA	"In California?"
NPL	"On NPL?"
FFA	"Signed FFA/IAG?"
R/U	"Re-Use Plan?"
EBS	"EBS Complete?"
OP?	"Still Operating?"
TYPE	"Installation Type"

FY95 DEPENDENT and EXPLANATORY VARIABLE INSTALLATION REGRESSION DATA

			COST DATA ($000)						SITES												ACREAGE & YEARS							CATEGORICAL					
Installation	ST	Type	$IC	IA $	RD $	$Rmd	$CC	$TC	Ttl	RC	S-c	S-u	IA-c	IA-u	D-c	D-u	C-c	C-u	H	M	ExcessA	InstlnA	EnvStA	UnStA	%UnStA	YTC	YRCI	CA	NPL	FFA	R/U	EBS	OP?
Agana	GU	NAS	17560	0	0	0	0	17560	29	0	0	29	22	2	0	0	0	0	1	5	2435	2435	0	2435	100.00%	5	12	0	0	0	0	1	1
Alameda	CA	NAS	35862	6471	64	122	6657	42519	30	0	0	3	0	8	0	0	0	0	14	9	2634	2634	0	2634	100.00%	5	7	1	0	1	0	0	1
Barber's Pt.	HI	NAS	18195	0	0	64	64	18259	23	4	4	19	0	1	0	0	0	0	4	12	2542	3759	0	2542	100.00%	5	11	0	0	0	0	1	1
Cecil	FL	NAS	10688	1064	336	697	2097	12785	25	2	6	19	5	4	0	2	2	1	14	6	17583	31366	16168	1415	8.05%	5	11	0	1	1	1	1	1
Davisville	RI	NCBC	21270	128	177	3532	3837	25107	24	5	10	14	1	0	3	5	2	3	8	8	1294	1294	518	776	59.97%	32	12	0	1	1	1	0	0
El Toro	CA	MCAS	28244	968	234	700	1902	30146	43	0	0	43	3	3	0	0	0	0	21	5	4776	4855	2992	1784	37.35%	4	11	1	1	1	0	1	1
Glenview	IL	NAS	4383	0	338	1673	2011	6394	35	1	1	33	0	0	0	0	0	0	11	20	1207	1208	285	922	76.39%	5	8	0	1	1	0	1	1
Hunter's Pt.	CA	NSY	81637	4077	3128	7943	15148	96785	63	5	5	58	9	2	0	0	0	0	22	28	936	936	88	848	90.60%	9	8	1	1	1	1	0	0
Long Beach	CA	NSTA	16672	527	0	0	527	17199	8	0	1	7	0	0	0	0	0	1	2	4	979	1533	200	779	79.57%	4	13	1	0	0	1	1	1
Mare Island	CA	NSY	27452	2391	37	1021	3449	30901	35	0	0	35	9	11	0	0	0	0	26	4	5646	5646	143	5503	97.47%	5	16	1	0	1	1	1	1
Moffett	CA	NAS	43839	2176	1279	4896	8351	52190	32	10	20	12	7	5	3	4	2	1	21	0	3700	3700	2514	1186	32.05%	7	12	1	1	1	1	1	0
Orlando	FL	NTC	6292	1072	0	1	1073	7365	15	2	4	11	0	1	0	0	0	1	3	2	2035	2035	1514	521	25.60%	5	11	0	0	0	0	1	1
San Diego	CA	NTC	5077	85	0	250	335	5412	13	1	3	10	2	2	2	0	0	2	1	2	420	522	292	128	30.48%	4	10	1	0	0	0	1	1
Trs. Island	CA	NSTA	6972	214	42	10	266	7238	31	3	3	28	3	3	0	0	0	0	14	5	717	1080	28	689	96.09%	5	8	1	0	1	0	1	1
Trenton	NJ	NAWC	6117	717	5	97	819	6936	11	2	2	9	2	2	1	2	2	2	3	0	54	54	21	33	61.11%	29	10	0	0	0	0	0	1
Tustin	CA	MCAS	4019	21640	26	5995	27661	31680	37	0	1	36	2	2	0	0	0	0	7	10	1383	1383	1301	82	5.93%	7	11	1	0	0	0	1	1
Warminster	PA	NAWC	3511	0	1041	1414	2455	5966	10	1	2	8	1	6	0	8	1	8	8	1	733	818	360	373	50.89%	31	16	0	1	1	0	1	1

CHART LEGEND

COST DATA

$IC	Total Cumulative Investigation Cost
$IA	Total Cumulative Interim Actions Cost
$RD	Total Cumulative Remedial Design Cost
$Rmd	Total Cumulative Remediation Cost
$CC	Total Cumulative Cleanup Category Cost ($CC = $IA + $RD + $Rmd)
$TC	Total Environmental Restoration Cost ($TC = $IC + $CC)

SITE DATA

Ttl	Total Number of Installation Sites
RC	Number of Sites w/Response Complete
S-c	Sites with Study Phase Complete
S-u	Sites with Study Phase Underway
IA-c	Number of Interim Actions Complete
IA-u	Number of Interim Actions Underway
D-c	Sites with Design Phase Complete
D-u	Sites with Design Phase Underway
C-c	Sites with Cleanup Phase Complete
C-u	Sites with Cleanup Phase Underway
H	Sites with Relative Risk - High
M	Sites with Relative Risk - Medium

ACREAGE & YEAR DATA

ExcessA	Excess Acreage
InstinA	Installation Acreage
EnvStA	Environmentally Suitable Acreage
UnStA	Unsuitable Acreage
%UnStA	% Unsuitable Acreage
YTC	Estimated Years-to-Complete
YRCI	Years Restoration Costs Incurred (number of years since first Restoration Costs were incurred)

CATEGORICAL

CA	"In California?"
NPL	"On NPL?"
FFA	"Signed FFA/IAG?"
R/U	"Re-Use Plan?"
EBS	"EBS Complete?"
OP?	"Still Operating?"
TYPE	"Installation Type"

FY94 DEPENDENT and EXPLANATORY VARIABLE INSTALLATION REGRESSION DATA

			COST DATA ($000)						SITES												ACREAGE & YEARS							CATEGORICAL					
Installation	ST	Type	$IC	IA $	RD $	$Rmd	$CC	$TC	Ttl	RC	S-c	S-u	IA-c	IA-u	D-c	D-u	C-c	C-u	H	M	ExcessA	InstlnA	EnvStA	UnStA	%UnStA	YTC	YRCI	CA	NPL	FFA	R/U	EBS	OP?
Agana	GU	NAS	8362	0	0	0	0	8362	23	0	0	23	0	0	0	0	0	0	n/a	n/a	2435	2435	0	2435	100.00%	9	11	0	0	0	0	1	1
Alameda	CA	NAS	29091	206	64	122	392	29483	24	0	0	24	0	2	0	0	0	0	n/a	n/a	2573	2573	77	2496	97.01%	11	6	1	0	0	0	0	1
Barber's Pt.	HI	NAS	14285	0	0	64	64	14349	21	4	4	17	0	0	0	0	0	0	n/a	n/a	2699	3759	0	2699	100.00%	9	10	0	0	0	0	1	1
Cecil	FL	NAS	5882	0	250	33	283	6165	25	1	2	23	5	0	0	0	1	1	n/a	n/a	20172	31366	18759	1413	7.00%	10	10	0	1	1	0	0	1
Davisville	RI	NCBC	17155	128	0	3410	3538	20693	23	3	5	18	3	0	3	2	1	3	n/a	n/a	1284	1284	154	1130	88.01%	6	11	0	1	1	1	0	0
El Toro	CA	MCAS	19742	2125	234	0	2359	22101	25	1	2	23	2	4	0	0	0	0	n/a	n/a	4776	4855	3738	1038	21.73%	9	10	1	1	1	0	0	1
Glenview	IL	NAS	3033	0	338	1422	1760	4793	30	0	0	29	0	0	0	0	0	0	n/a	n/a	1208	1208	266	942	77.98%	7	7	0	1	1	0	0	1
Hunter's Pt.	CA	NSY	69787	0	806	7943	8749	78536	64	3	3	61	12	0	0	1	0	0	n/a	n/a	937	937	49	888	94.77%	10	7	1	1	1	0	0	0
Long Beach	CA	NSTA	12522	527	0	0	527	13049	9	0	0	9	0	1	0	0	0	1	n/a	n/a	1533	1533	245	1288	84.02%	11	12	1	0	0	1	1	1
Mare Island	CA	NSY	25513	63	37	1021	1121	26634	42	0	0	42	10	1	0	0	0	0	n/a	n/a	5646	5646	226	5420	96.00%	12	15	1	0	1	1	0	1
Moffett	CA	NAS	39749	0	0	4896	4896	44645	32	2	2	27	6	2	0	6	0	0	n/a	n/a	3067	3067	2490	577	18.81%	8	11	1	1	1	1	0	1
Orlando	FL	NTC	1830	0	0	1	1	1831	15	4	5	9	0	1	0	0	0	0	n/a	n/a	2110	2150	1289	821	38.91%	9	10	0	0	0	0	0	1
San Diego	CA	NTC	3335	0	0	250	250	3585	7	0	0	7	0	2	0	2	0	2	n/a	n/a	389	522	277	112	28.79%	5	9	1	0	0	0	0	1
Trs. Island	CA	NSTA	4339	214	42	10	266	4605	51	5	5	46	21	6	0	1	0	0	n/a	n/a	1080	1080	32	1048	97.04%	10	7	1	0	1	0	0	1
Trenton	NJ	NAWC	5726	0	5	50	55	5781	11	2	2	9	2	1	1	4	2	0	n/a	n/a	54	54	26	28	51.85%	9	9	0	0	0	0	1	1
Tustin	CA	MCAS	4019	15436	26	0	15462	19481	32	15	17	15	3	1	0	0	0	1	n/a	n/a	1383	1383	0	1383	100.00%	10	10	1	0	0	0	1	1
Warminster	PA	NAWC	2747	0	263	1139	1402	4149	10	1	9	1	1	0	7	1	1	0	n/a	n/a	818	818	401	417	50.98%	14	15	0	1	1	0	0	1

CHART LEGEND

COST DATA

$IC	Total Cumulative Investigation Cost
$IA	Total Cumulative Interim Actions Cost
$RD	Total Cumulative Remedial Design Cost
$Rmd	Total Cumulative Remediation Cost
$CC	Total Cumulative Cleanup Category Cost ($CC = $IA + $RD + $Rmd)
$TC	Total Environmental Restoration Cost ($TC = $IC + $CC)

SITE DATA

Ttl	Total Number of Installation Sites
RC	Number of Sites w/Response Complete
S-c	Sites with Study Phase Complete
S-u	Sites with Study Phase Underway
IA-c	Number of Interim Actions Complete
IA-u	Number of Interim Actions Underway
D-c	Sites with Design Phase Complete
D-u	Sites with Design Phase Underway
C-c	Sites with Cleanup Phase Complete
C-u	Sites with Cleanup Phase Underway
H	Sites with Relative Risk - High
M	Sites with Relative Risk - Medium

ACREAGE & YEAR DATA

ExcessA	Excess Acreage
InstlnA	Installation Acreage
EnvStA	Environmentally Suitable Acreage
UnStA	Unsuitable Acreage
%UnStA	% Unsuitable Acreage
YTC	Estimated Years-to-Complete
YRCI	Years Restoration Costs Incurred (number of years since first Restoration Costs were incurred)

CATEGORICAL

CA	"In California?"
NPL	"On NPL?"
FFA	"Signed FFA/IAG?"
R/U	"Re-Use Plan?"
EBS	"EBS Complete?"
OP?	"Still Operating?"
TYPE	"Installation Type"

APPENDIX B. FORECAST MODEL REGRESSION RESULTS

For purposes of forecast model development, a total of 17 DoN facilities met all the selective data conditions. Extensive parametric data were compiled for each of the 17 facilities over the FY94-FY96 period yielding a total of 51 autonomous data points. Each installation data point, over each of the three years, entails multiple explanatory variables with which to build the regression model.

This appendix details the multiple regression statistical results and graphical presentations for the environmental restoration forecast model considered to be the most significant and reliable estimator. After multiple iterative regressions on all three dependent variables over all possible explanatory variable combinations, the $TC model clearly proved to be the must statistically significant. The specific estimating model presented in this appendix is the multiple regression on the transformed dependent variable of Total Cumulative Environmental Restoration Cost ("logt ($TC)").

The multiple regression computations and analytical tests were performed using the commercially produced MINITAB Statistical Analysis software package. The data and graphical representations displayed in this appendix are outputs of the MINITAB system.

DISTRIBUTION of TOTAL CUMULATIVE RESTORATION COST ("$TC")

```
MTB > hist c2
```

Character Histogram

```
Histogram of $TC    N = 51

Midpoint   Count
       0       5  *****
   10000      18  ******************
   20000      10  **********
   30000       9  *********
   40000       3  ***
   50000       2  **
   60000       1  *
   70000       0
   80000       1  *
   90000       0
  100000       1  *
  110000       1  *
```

DISTRIBUTION of the TRANSFORMATION OF $TC - "logt ($TC)"

```
MTB > hist c3
```

Character Histogram

```
Histogram of logt$TC    N = 51

Midpoint   Count
     3.2       1  *
     3.4       0
     3.6       4  ****
     3.8       9  *********
     4.0       6  ******
     4.2      10  **********
     4.4       9  *********
     4.6       6  ******
     4.8       4  ****
     5.0       2  **
```

FINAL REGRESSION INFORMATION for "$TC"

```
info
```

Information on the Worksheet

Column	Count	Name
C1	51	Instaln
C2	51	$TC
C3	51	logt$TC
C4	51	Sts(T)
C5	51	Sts(C)
C6	51	Unst.A
C7	51	CA?
C8	51	NPL
C9	51	FFA
C10	51	R/U
C20	51	Residual
C21	51	Expctd Y
C22	51	norm rsdl

CORRELATION MATRIX for EXPLANATORY VARIABLES

```
corr c4-c10
```

Correlations (Pearson)

	Sts(T)	Sts(C)	Unst.A	CA?	NPL	FFA
Sts(C)	-0.247					
Unst.A	0.252	-0.296				
CA?	0.392	-0.167	0.133			
NPL	0.325	0.349	-0.258	-0.169		
FFA	0.511	0.179	0.149	0.131	0.729	
R/U	0.095	0.167	0.120	0.102	0.169	0.266

FORECAST MODEL REGRESSION DATA for "$TC"

	C1 Instaln	C2 $TC	C3 logt$TC	C4 Sts(T)	C5 Sts(C)	C6 Unst.A	C7 CA?	C8 NPL	C9 FFA	C10 R/U
1	Agana	18667	4.27107	30	0	2435	0	0	0	1
2	Alameda	52461	4.71984	30	4	2628	1	0	1	1
3	Barbers	18263	4.26157	25	2	2542	0	0	0	0
4	Cecil	16876	4.22727	25	2	1350	0	1	1	1
5	DavisV	29927	4.47606	25	7	776	0	1	1	1
6	El Toro	35778	4.55362	43	8	1346	1	1	1	0
7	Glenvw	11639	4.06592	36	1	396	0	1	1	1
8	Hunters	114745	5.05973	74	0	848	1	1	1	1
9	L.Bch	24530	4.38970	9	2	848	1	0	0	1
10	Mare	34522	4.53810	36	0	5195	1	0	1	1
11	Moffett	58269	4.76544	34	7	583	1	1	1	1
12	Orlando	7970	3.90146	14	1	520	0	0	0	1
13	SD	7060	3.84880	14	2	0	1	0	0	0
14	TI	8979	3.95323	31	0	639	1	0	1	1
15	Trenton	8544	3.93166	11	3	33	0	0	0	1
16	Tustin	32221	4.50814	28	3	82	1	0	0	1
17	Wrmnstr	11362	4.05545	10	3	419	0	1	1	1
18	Agana	17560	4.24452	29	0	2435	0	0	0	0
19	Alameda	42519	4.62858	30	0	2634	1	0	1	0
20	Barbers	18259	4.26148	23	0	2542	0	0	0	0
21	Cecil	12785	4.10670	25	3	1415	0	1	1	1
22	DavisV	25107	4.39979	24	5	776	0	1	1	1
23	El Toro	30146	4.47923	43	0	1784	1	1	1	0
24	Glenvw	6394	3.80577	35	0	922	0	1	1	0
25	Hunters	96785	4.98581	63	0	848	1	1	1	1
26	L.Bch	17199	4.23550	8	1	779	1	0	0	1
27	Mare	30901	4.48997	35	0	5503	1	0	1	1
28	Moffett	52190	4.71759	32	3	1186	1	1	1	1
29	Orlando	7365	3.86717	15	1	521	0	0	0	0
30	SD	5412	3.73336	13	2	128	1	0	0	0
31	TI	7238	3.85962	31	0	689	1	0	1	0
32	Trenton	6936	3.84111	11	4	33	0	0	0	0
33	Tustin	31680	4.50079	37	0	82	1	0	0	0
34	Wrmnstr	5966	3.77568	10	9	373	0	1	1	0
35	Agana	8362	3.92231	23	0	2435	0	0	0	0
36	Alameda	29483	4.46957	24	0	2496	1	0	0	0
37	Barbers	14349	4.15682	21	0	2699	0	0	0	0
38	Cecil	6165	3.78993	25	2	1413	0	1	1	0
39	DavisV	20693	4.31582	23	4	1130	0	1	1	1
40	El Toro	22101	4.34441	25	0	1038	1	1	1	0
41	Glenvw	4793	3.68061	30	0	942	0	1	1	0
42	Hunters	78536	4.89507	64	0	888	1	1	1	0
43	L.Bch	13049	4.11558	9	1	1288	1	0	0	1
44	Mare	26634	4.42544	42	0	5420	1	0	1	1
45	Moffett	44645	4.64977	32	0	577	1	1	1	1
46	Orlando	1831	3.26269	15	0	821	0	0	0	0
47	SD	3585	3.55449	7	2	112	1	0	0	0
48	TI	4605	3.66323	51	0	1048	1	0	1	0
49	Trenton	5781	3.76200	11	2	28	0	0	0	0
50	Tustin	19481	4.28961	32	1	1383	1	0	0	0
51	Wrmnstr	4149	3.61794	10	1	417	0	1	1	0

MULTIPLE REGRESSION RESULTS for TRANSFORMED $TC - "logt($TC)"

```
MTB > regr c3 7 c4 c5 c6 c7 c8 c9 c10 c20 c21;
SUBC> xlof;
SUBC> dw.
```

Regression Analysis

```
The regression equation is
logt$TC = 3.39 + 0.0142 Sts(T) + 0.0388 Sts(C) +0.000116 Unst.A + 0.317 CA?
          + 0.429 NPL - 0.460 FFA + 0.261 R/U

Predictor        Coef        StDev          T        P
Constant      3.39478      0.08250      41.15    0.000
Sts(T)       0.014169     0.002905       4.88    0.000
Sts(C)        0.03877      0.01605       2.42    0.020
Unst.A     0.00011578   0.00002966       3.90    0.000
CA?           0.31660      0.07344       4.31    0.000
NPL            0.4293       0.1205       3.56    0.001
FFA           -0.4597       0.1135      -4.05    0.000
R/U           0.26135      0.06380       4.10    0.000

S = 0.2143       R-Sq = 75.1%      R-Sq(adj) = 71.1%

Analysis of Variance

Source        DF          SS          MS         F        P
Regression     7     5.96901     0.85272     18.57    0.000
Error         43     1.97493     0.04593
Total         50     7.94394

Source        DF      Seq SS
Sts(T)         1     3.15284
Sts(C)         1     0.36115
Unst.A         1     0.38570
CA?            1     0.59449
NPL            1     0.10282
FFA            1     0.60140
R/U            1     0.77060

Unusual Observations
Obs     Sts(T)     logt$TC         Fit   StDev Fit    Residual    St Resid
 19       30.0      4.6286      3.9817      0.0877      0.6469       3.31R
 46       15.0      3.2627      3.7024      0.0619     -0.4397      -2.14R
 48       51.0      3.6632      4.0956      0.1125     -0.4324      -2.37R

R denotes an observation with a large standardized residual

Durbin-Watson statistic = 1.78

Lack of fit test
Possible interactions with variable Unst.A (P = 0.059)
Overall lack of fit test is significant at P = 0.059
```

"RESIDUAL versus FIT" PLOT

- Certain assumptions are asserted and tested during regression model construction. The assumptions provide the justification for the widespread applicability of the regression method. Meeting the regression assumptions validates that the resulting model estimators are unbiased, consistent, and efficient. Thus, an understanding of these assumptions is vital so that regression modeling can be employed and analyzed in the proper manner.

- The validity of two of the key regression assumptions - Linearity & Homoscedasticity - is confirmed by the examination of a regression's "Residual versus Fit" plot. The Linearity assumption states that the dependent variable is linearly related to each of the explanatory variables. The Homoscedasticity assumption states that the error terms are assumed to have a finite variance that is constant for all given values of explanatory variables.

- The "Residual versus Fit" plot, as shown below, removes the effect of the regression line and thus, amplifies the underlying patterns difficult to detect when the regression line dominates. The "Residual versus Fit" plot allows us to pinpoint violations of Linearity & Homoscedasticity by showing model characteristics not normally captured in a plot of dependent versus explanatory variables. In anaylzing a "Residual versus Fit" plot, a random pattern of errors shows the linearity of the model was entirely captured in the dependent to explanatory variable relationship. Therefore, a random pattern as displayed below, validates the Linearity & Homoscedasticity (or Constant Variance) assumptions.
(Note: Numbers within the graph denote multiple data points)

```
plot c20 c21
```

Character Plot

```
         -
 Residual-                  *
         -
         -
      2.0+
         -                                *
         -                   *       *             *
         -      *  2      * *  ** *  *  2   *
         -           *              * *           *        *
      0.0+     *          *        **        2        *          *
         -                 ***          2        *
         -               * 2*       ***           *
         -               *  *                         *
         -               *                           *
     -2.0+        *
         -                      *
         -
           ----+---------+---------+---------+---------+---------+--Expctd Y
            3.60      3.90      4.20      4.50      4.80      5.10
```

"NORMAL PROBABILITY" PLOT

- Certain assumptions are asserted and tested during regression model construction. The assumptions provide the justification for the widespread applicability of the regression method. Meeting the regression assumptions validate that the resulting model estimators are unbiased, consistent, and efficient. Thus, an understanding of these assumptions is vital so that regression modeling can be employed and analyzed in the proper manner.

- The validity of a key regression assumption - Normality of Error Distribution - is confirmed by the examination of a regression's "Normal Probability" plot. The Normality of Error Distribution assumption states that the error terms from a properly conducted regression estimation should be normally distributed. Since error terms are a composite of many factors not included in the regression equation, it is reasonable to expect that many of these factors may tend to offset each other. This offsetting effect is exactly the pattern described by a normal probability curve. The factors affecting the regression include model errors (i.e., measurement, model specification, causality errors) or irregular errors (i.e., cyclical fluctuations or budgetary fluctuations). If many of these factors are unrelated, one form of Central Limit theorem assures that their joint effects (represented by error terms) will be normally distributed.

- The "Normal Probability" plot (see below) tests the normality of the residuals distribution. To construct the plot, normal scores ("nscore") are calculated for the error terms of the regression equation. The normal scores are then plotted against the error terms. If the residuals are from a normally distributed population, then a "residual versus normal scores" plot will lie roughly in a straight 45 degree line. Thus, a roughly 45 degree straight line, as seen below, validates the Normality of Error Distribution assumption. (Note: Numbers within the graph denote multiple data points)

```
nscore c20 c22
plot c20 c22
```

Character Plot

```
         -
         -
 Residual-                                                    *
         -
         -
      2.0+
         -                                                *
         -                                          * **
         -                                  222**2**
         -                               22*
      0.0+                           *232
         -                        2*2*
         -                   2**22
         -                ***
         -             **
     -2.0+          *
         -      *
         -
           --------+---------+---------+---------+---------+--------norm rsd
                -2.0      -1.0       0.0       1.0       2.0
```

```
corr c20 c22

Correlation of Residual and norm rsdl = 0.981
```

APPENDIX C. FORECAST MODEL VALIDATION DATA AND RESULTS

In order to confirm the functionality of the developed forecast model for DoN BRAC installations, comparative analysis of estimated versus actual costs was undertaken. Both the developed forecast model estimates and DoN's planning estimates were compared against actual costs to determine prediction variances.

Expenditure data from all 17 installations utilized in forecast model development were employed in the comparative analysis. Actual FY95 and FY96 environmental restoration cost data came from the respective year's DERP Annual Report to Congress. Similarly, the cost data for "DoN's Planning Estimate" also came from DERP reports. The "Forecast Model Estimate" values were calculated from individual installation parameters utilizing the prediction equation generated in forecast model development (as described in Chapter IV).

This appendix displays the installation data compiled and evaluated in the forecasted environmental restoration cost variance comparative analyses.

FY96 Forecast Model Validation Comparative Analysis Data and Results

Installation	Sts(T)	Sts(C)	Unst.A	CA?	NPL	FFA	R/U	logt($TC)	Estimates ($000) Model Est	DoN Est	96 (A)	Additive Variance Model %	DoN %	Absolute Value Variance Model %	DoN %
Agana	30	0	2435	0	0	0	1	4.3631	$ 23,074	$ 10,120	$ 18,667	23.61%	-45.79%	23.61%	45.79%
Alameda	30	4	2628	1	0	1	1	4.3974	$ 24,972	$ 42,595	$ 52,461	-52.40%	-18.81%	52.40%	18.81%
Barbers	25	2	2542	0	0	0	0	4.1209	$ 13,209	$ 26,703	$ 18,263	-27.68%	46.21%	27.68%	46.21%
Cecil	25	2	1350	0	1	1	1	4.2138	$ 16,361	$ 19,310	$ 16,876	-3.05%	14.42%	3.05%	14.42%
DavisV	25	7	776	0	1	1	1	4.3412	$ 21,938	$ 28,696	$ 29,927	-26.70%	-4.11%	26.70%	4.11%
El Toro	43	8	1346	1	1	1	0	4.7562	$ 57,049	$ 43,374	$ 35,778	59.45%	21.23%	59.45%	21.23%
Glenview	36	1	396	0	1	1	1	4.2204	$ 16,612	$ 7,082	$ 11,639	42.73%	-39.15%	42.73%	39.15%
Hunters	74	0	848	1	1	1	1	5.0890	$ 122,749	$ 102,432	$114,745	6.98%	-10.73%	6.98%	10.73%
Long bch	9	2	848	1	0	0	1	4.2760	$ 18,879	$ 64,365	$ 24,530	-23.04%	162.39%	23.04%	162.39%
Mare	36	0	5195	1	0	1	1	4.6246	$ 42,130	$ 72,668	$ 34,522	22.04%	110.50%	22.04%	110.50%
Moffet	34	7	583	1	1	1	1	4.7630	$ 57,938	$ 52,104	$ 58,269	-0.57%	-10.58%	0.57%	10.58%
Orlando	14	1	520	0	0	0	1	3.9535	$ 8,984	$ 5,217	$ 7,970	12.72%	-34.54%	12.72%	34.54%
SD	14	2	0	1	0	0	0	3.9873	$ 9,711	$ 7,321	$ 7,060	37.56%	3.70%	37.56%	3.70%
TI	31	0	639	1	0	1	1	4.0263	$ 10,623	$ 7,755	$ 8,979	18.31%	-13.63%	18.31%	13.63%
Trenton	11	3	33	0	0	0	1	3.9321	$ 8,553	$ 6,377	$ 8,544	0.11%	-25.36%	0.11%	25.36%
Tustin	28	3	82	1	0	0	1	4.4953	$ 31,280	$ 22,581	$ 32,221	-2.92%	-29.92%	2.92%	29.92%
Warmnstr	10	3	419	0	1	1	1	3.9322	$ 8,555	$ 15,271	$ 11,362	-24.70%	34.40%	24.70%	34.40%
											SUM	62.45%	160.23%	384.55%	625.48%
											AVE	3.67%	9.43%	22.62%	36.79%

CHART LEGEND

Sts(T)	Total Number of Installation Sites	logt($TC)	Logarithmic Transformation of $TC
Sts(C)	Sites w/ Cleanup Phase Complete/Underway	$TC	Total Cumulative Restoration Cost
UnstA	Unsuitable Acreage	Model Est	Developed Forecast Model Estimate
CA?	Installation State (i.e. In California?)	DoN Est	DoN's Expenditure Planning Estimate
NPL	EPA's National Priorities List	96(A)	Actual FY96 Total Restoration Cost ($TC)
FFA	Federal Facilities Agreement	Model %	Cost Variance Percentage for Model Estimates
R/U	Re-Use Plan	DoN %	Cost Variance Percentage for DoN Estimates

FY95 Forecast Model Validation Comparative Analysis Data and Results

Installation	Sts(T)	Sts(C)	Unst.A	CA?	NPL	FFA	R/U	logt($TC)	Estimates ($000) Model Est	DoN Est	95 (A)	Additive Variance Model %	DoN %	Absolute Value Variance Model %	DoN %
Agana	29	0	2435	0	0	0	0	4.0876	$ 12,235	$ 8,646	$ 17,560	-30.32%	-50.76%	30.32%	50.76%
Alameda	30	0	2634	1	0	1	0	3.9817	$ 9,588	$ 16,543	$ 42,519	-77.45%	-61.09%	77.45%	61.09%
Barbers	23	0	2542	0	0	0	0	4.0150	$ 10,351	$ 3,062	$ 18,259	-43.31%	-83.23%	43.31%	83.23%
Cecil	25	3	1415	0	1	1	1	4.2601	$ 18,201	$ 23,596	$ 12,785	42.36%	84.56%	42.36%	84.56%
DavisV	24	5	776	0	1	1	1	4.2495	$ 17,762	$ 23,642	$ 25,107	-29.26%	-5.84%	29.26%	5.84%
El Toro	43	0	1784	1	1	1	0	4.4968	$ 31,391	$ 8,942	$ 30,146	4.13%	-70.34%	4.13%	70.34%
Glenview	35	0	922	0	1	1	0	3.9670	$ 9,269	$ 3,960	$ 6,394	44.97%	-38.07%	44.97%	38.07%
Hunters	63	0	848	1	1	1	1	4.9332	$ 85,735	$ 96,894	$ 96,785	-11.42%	0.11%	11.42%	0.11%
Long bch	8	1	779	1	0	0	1	4.2150	$ 16,408	$ 24,719	$ 17,199	-4.60%	43.72%	4.60%	43.72%
Mare	35	0	5503	1	0	1	1	4.6461	$ 44,267	$ 54,958	$ 30,901	43.26%	77.85%	43.26%	77.85%
Moffet	32	3	1186	1	1	1	1	4.6494	$ 44,603	$ 54,261	$ 52,190	-14.54%	3.97%	14.54%	3.97%
Orlando	15	1	521	0	0	0	0	3.7064	$ 5,086	$ 1,153	$ 7,365	-30.94%	-84.34%	30.94%	84.34%
SD	13	2	128	1	0	0	0	3.9879	$ 9,726	$ 4,072	$ 5,412	79.71%	-24.76%	79.71%	24.76%
TI	31	0	689	1	0	1	0	3.7707	$ 5,898	$ 7,650	$ 7,238	-18.52%	5.69%	18.52%	5.69%
Trenton	11	4	33	0	0	0	0	3.7095	$ 5,123	$ 3,206	$ 6,936	-26.14%	-53.78%	26.14%	53.78%
Tustin	37	0	82	1	0	0	0	4.2451	$ 17,584	$ 21,931	$ 31,680	-44.49%	-30.77%	44.49%	30.77%
Warmnstr	10	9	373	0	1	1	0	3.8982	$ 7,910	$ 5,912	$ 5,966	32.59%	-0.91%	32.59%	0.91%
											SUM	-83.97%	-287.98%	578.00%	719.79%
											AVE	-4.94%	-16.94%	34.00%	42.34%

CHART LEGEND

Sts(T)	Total Number of Installation Sites	logt($TC)	Logarithmic Transformation of $TC
Sts(C)	Sites w/ Cleanup Phase Complete/Underway	$TC	Total Cumulative Restoration Cost
UnstA	Unsuitable Acreage	Model Est	Developed Forecast Model Estimate
CA?	Installation State (i.e. In California?)	DoN Est	DoN's Expenditure Planning Estimate
NPL	EPA's National Priorities List	95(A)	Actual FY95 Total Restoration Cost ($TC)
FFA	Federal Facilities Agreement	Model %	Cost Variance Percentage for Model Estimates
R/U	Re-Use Plan	DoN %	Cost Variance Percentage for DoN Estimates

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