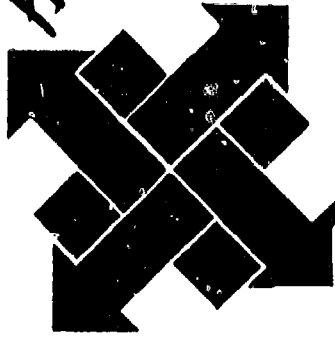


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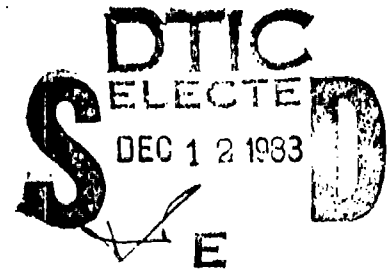
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Analysis of Cost Growth at Naval Shipyards

FY79 - FY82

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Final Report
November, 1983

Analysis of Cost Growth at Naval Shipyards
FY79 - FY82

Ms. M. Curtin
Ms. E. Krochalis
Mr. J. Lobi

The Defense Studies Department

MATHTECH, Inc.
1401 Wilson Boulevard
Arlington, Virginia 22209
(703) 243-2210

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EXECUTIVE SUMMARY

✓
The objectives of this study are to determine if and where growth in Navy shipyard costs has occurred between FY79 and FY82 and if the growth was justified. In general, our analysis shows actual costs increased 55%, but when adjusted for inflation, the growth was 22%. For the same time period, total shipyard labor hours increased 19%. When expressed in constant dollars per direct labor hour, unit costs increased 4% over the four year period.

More specifically, our analysis shows that indirect costs grew as fast as or faster than direct costs for five shipyards. Indirect labor hours grew at a faster rate than direct hours for the combined eight shipyards and for at least half of the individual shipyards. We also discovered that contracting costs grew significantly. These facts plus the large growth in labor hours led to the question whether the increased labor hours themselves were justified on the basis of "true" output, i.e., whether or not this increased labor produced commensurate increases in quantities and quality of shipyard output. Indeed, this concern was expressed by the Chief of Naval Operations in a recent Memorandum, which was sent to the Commanders in Chief of the Atlantic and Pacific Fleets and to the Chief of Navy Material, discussing the effects of increases in submarine overhaul costs, durations, and mandays.¹

At the present time, it is not possible to link true shipyard output measures to labor and costs contained in the shipyard Financial and Operating (F&O) Statements. This inability arises because output measures, such as overhauls, are expressed on an induction basis, while both money and hours are accounted for on an accrual basis as the work is performed. The F&O statements do not

¹ CNO Memo Serial 00/3U300192 of 23 May, 1983.

relate total shipyard output (by hull, by function, and non-shipwork) to planned and actual costs and labor hours on a fiscal year basis.

For this reason, it was not possible to analyze the "labor-to-output" problem directly. Instead, the analysis used various surrogates for true output such as workload complexity and aggregate planned (budget) manday workload. Analysis based on these surrogates, however, was inconclusive with respect to the question of whether or not shipyard labor growth was justified. It also did not explain the faster growth in indirect labor hours and costs. This unexpected growth in indirect elements may imply that adequate controls are not being exercised in this area of shipyard operations. The present accounting structure does not provide managers with the information they need to control indirect costs.

To improve the management of shipyard operations, an aspect of which includes the ability to perform the kinds of analyses undertaken in this report, several fundamental changes in shipyard management practice should be considered:

- o Develop Shipyard Output Measures. The Navy presently measures output in terms of the number of overhauls and RA/TAs, total costs, and direct labor mandays. More refined output measures are needed that have a functional orientation. While the implementation of output measures will be a difficult, evolutionary process, there are some indications, which are discussed in Section 4, that these measures can be developed.
- o Establish a Policy to Control Shipyard Indirect Hours. The underlying causes for growth in indirect hours cannot be determined using the data presented in the shipyard F&O statements. Currently indirect labor hours are reported against cost classifications, which have an "element of expense" orientation, and are not useful for determining the functional purposes for which indirect hours are incurred. The first step to control indirect labor hour growth is to conduct an analysis which identifies the functional reasons for incurring indirect hours. Then, several policy options can be considered. One option that may be useful is to re-align the reporting structure so that all labor hours which can be directly related to specific

customers are charges to direct labor. Another option may be to limit indirect growth in specific areas or to limit overall indirect growth to a prescribed function of direct hours or to previous years' indirect costs. However, regardless of the options selected, the cost classification structure should be revised to reflect more accurately the functional purpose for indirect labor hour charges.

- o Develop an Improved Financial Management Report for Shipyards.
This report would be aimed at managers at OPNAV and NAVSEA levels. It would organize, convert, and add new data to the existing shipyard Financial and Operating (F&O) Statements that would express shipyard performance in terms familiar to Navy program managers. Data for both hours and costs by direct and indirect would be shown by significant categories of shipwork. It would show the percentage completion and identify any variances from plan. This level of data, which is available in each shipyard's management system, would integrate fiscal data with program information and provide a clearer picture of shipyard operations.

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Section 1

INTRODUCTION

↙ In January, 1983, MATHTECH began an analysis of Navy Industrial Fund (NIF) Operating Support Costs for Naval Shipyards. Early in our discussions with Navy personnel, we learned that the shipyards were losing money. In FY82, the total costs of goods and services provided by all eight shipyards exceeded the total revenues received by \$105 million. Furthermore, NAVSEA sources say that the shipyards are expected to lose an additional \$150 million in FY83.

Two opposing explanations have been given for these losses. One group of observers maintains that the rates charged by the shipyards to their customers have been artificially depressed to keep the costs of ship overhaul and alterations programs down. Consequently they claim that shipyards are not able to pass on the actual cost of work packages to the customers. This group also maintains that this problem has been exacerbated by the increased number of mandated programs, such as EEO, OSHA and Medicare because these costs cannot be immediately passed on to their customers. A second contingent claims that shipyard losses are driven by excessive shipyard overhead costs, particularly in the General and Administrative (G&A) area. Their concern is that the growth in these costs is unjustified, uncontrolled, and the major contributor to the losses being experienced by the shipyards.

➤ This study focuses on the concern regarding excessive cost growth, particularly overhead costs. For each of the eight shipyards, we analyzed the relationships and trends of direct and indirect costs and labor hours between FY79 and FY82. The Shipyard Financial and Operating (F&O) statements provide extensive data on overhead costs and were our primary data source. ... source

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↓

We began our analysis by examining shipyard cost composition and growth and found that most of the cost increases were attributable to labor increases. In the ~~next~~ ^{then} section of ~~this report~~ we discuss labor hour findings and review some workload indicators. The behavior of shipyard costs follows in ~~Section 3~~ ^{Section 3}, and observations and conclusions are presented in ~~Section 4~~ ^{Section 4}. More detailed explanations of labor hour and cost growth are addressed in Appendices A and B, respectively.

↑

Section 2

LABOR HOUR TRENDS

This section describes the growth in direct and indirect labor hours, looks at workload complexity measures and planned workload growth in labor hours, and discusses the cost implications of growth in indirect labor hours.

Growth in Direct and Indirect Labor Hours

Both direct and indirect labor hours increased significantly from FY79 to FY82. Direct labor hours for all shipyards increased 17% from 73.8M in FY79 to 86.1M in FY82. As Figure 2-1 indicates, direct labor hours increased most at Philadelphia and Mare Island and least at Charleston. Table A-1 in Appendix A lists the direct labor hours incurred at each shipyard during the four year period.

Indirect labor for the combined eight shipyards grew faster than direct labor hours. Total indirect labor hours increased 22% from 52.7M in FY79 to 64.2M in FY82. As indicated on Figure 2-2, indirect labor hours grew most at Philadelphia and Pearl Harbor and least at Long Beach. Table A-2 in Appendix A lists the indirect labor hours for each shipyard. Indirect labor includes hours for supervision, training, time allowed, planning and G&A functions. Usually, the rate of indirect growth is expected to be less than direct since overhead functions need not increase proportionately. Consequently, faster growth in indirect hours is counter-intuitive and needed further analyses.

To verify our initial observations about growth patterns, we performed a simple regression of both indirect and direct labor hours against time. The

Figure 2-1

DIRECT LABOR HOURS BY SHIPYARD FROM FY79-FY82

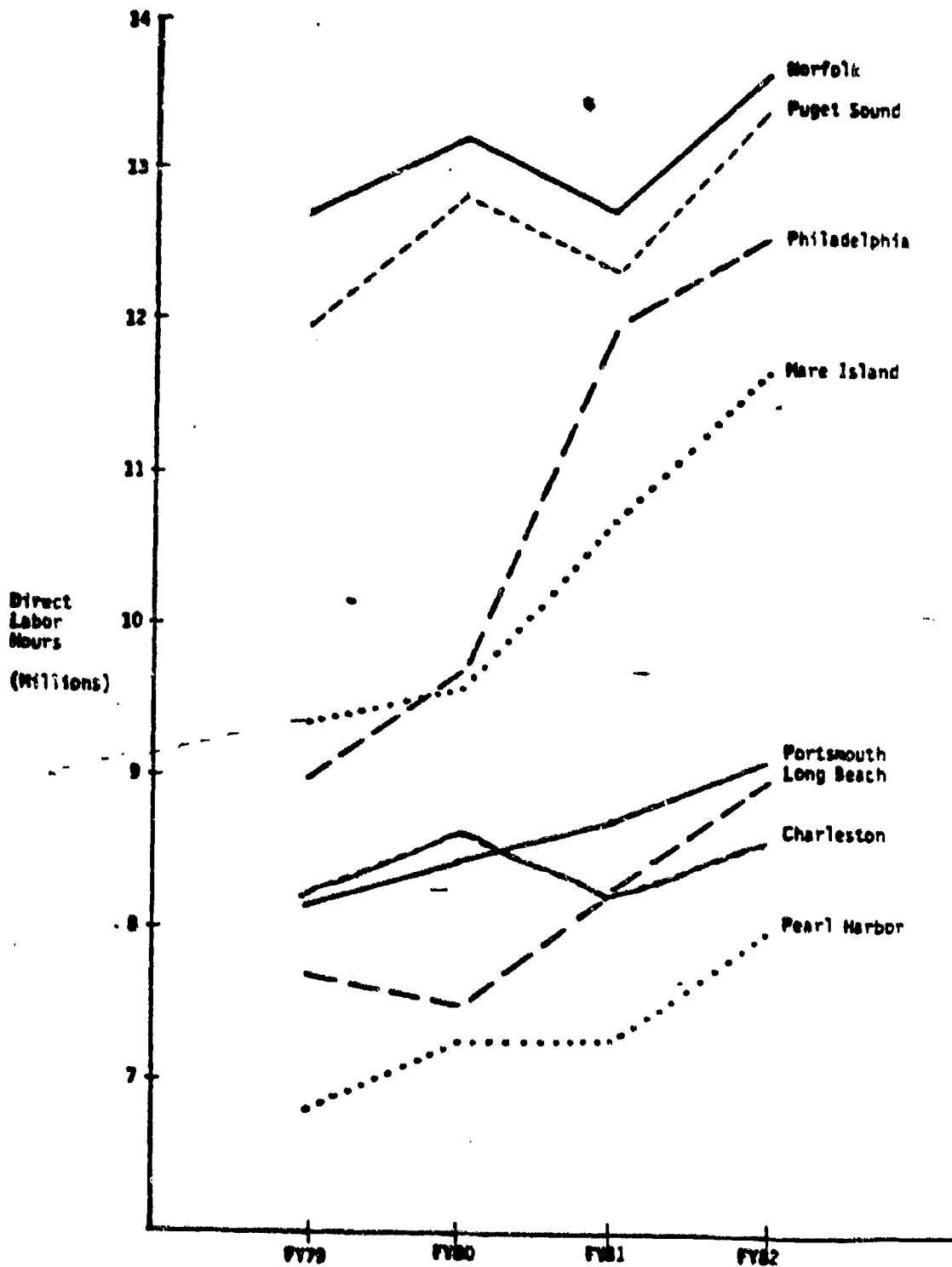


Figure 2-2

INDIRECT LABOR HOURS BY SHIPYARD
FROM FY79-FY82

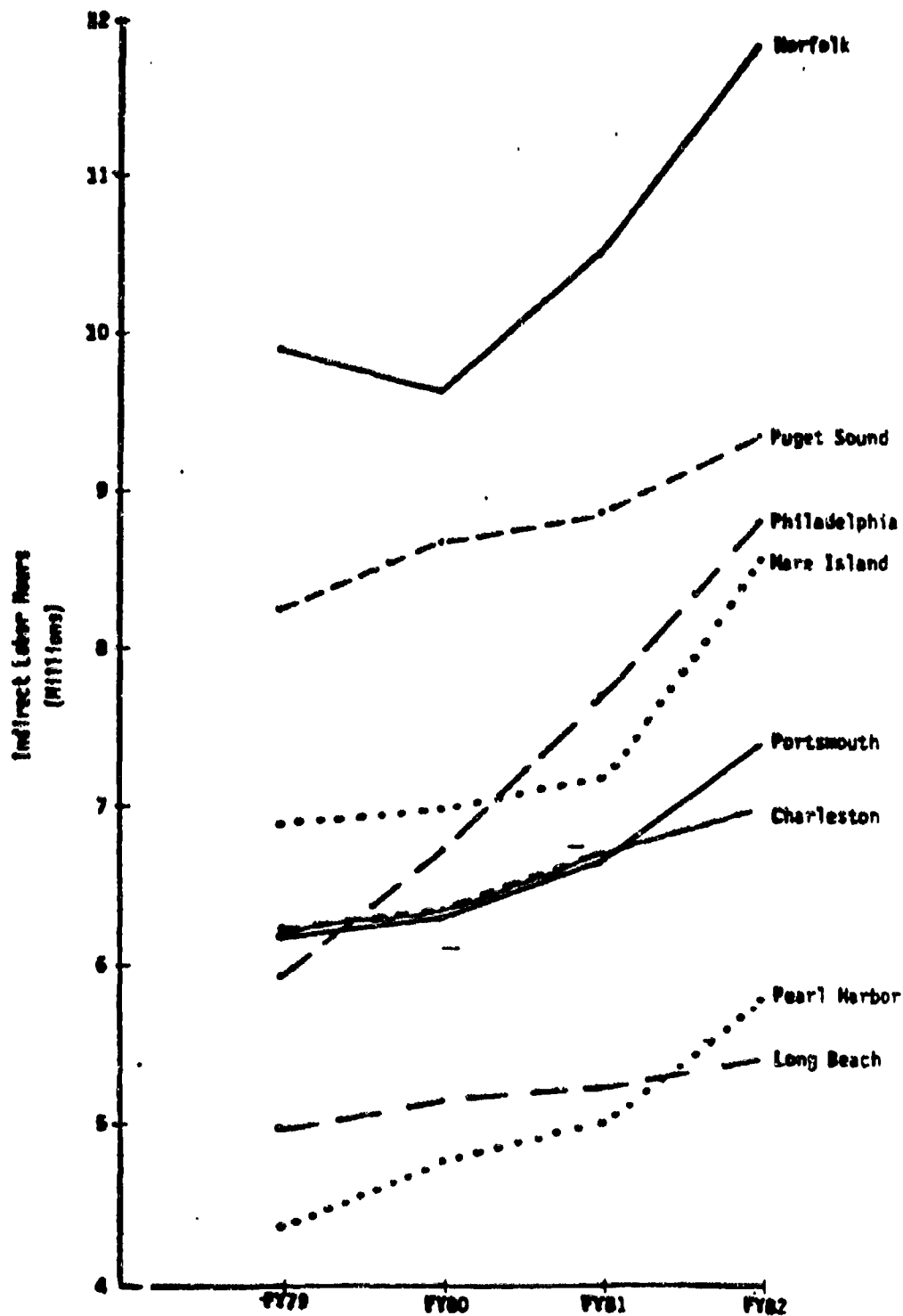
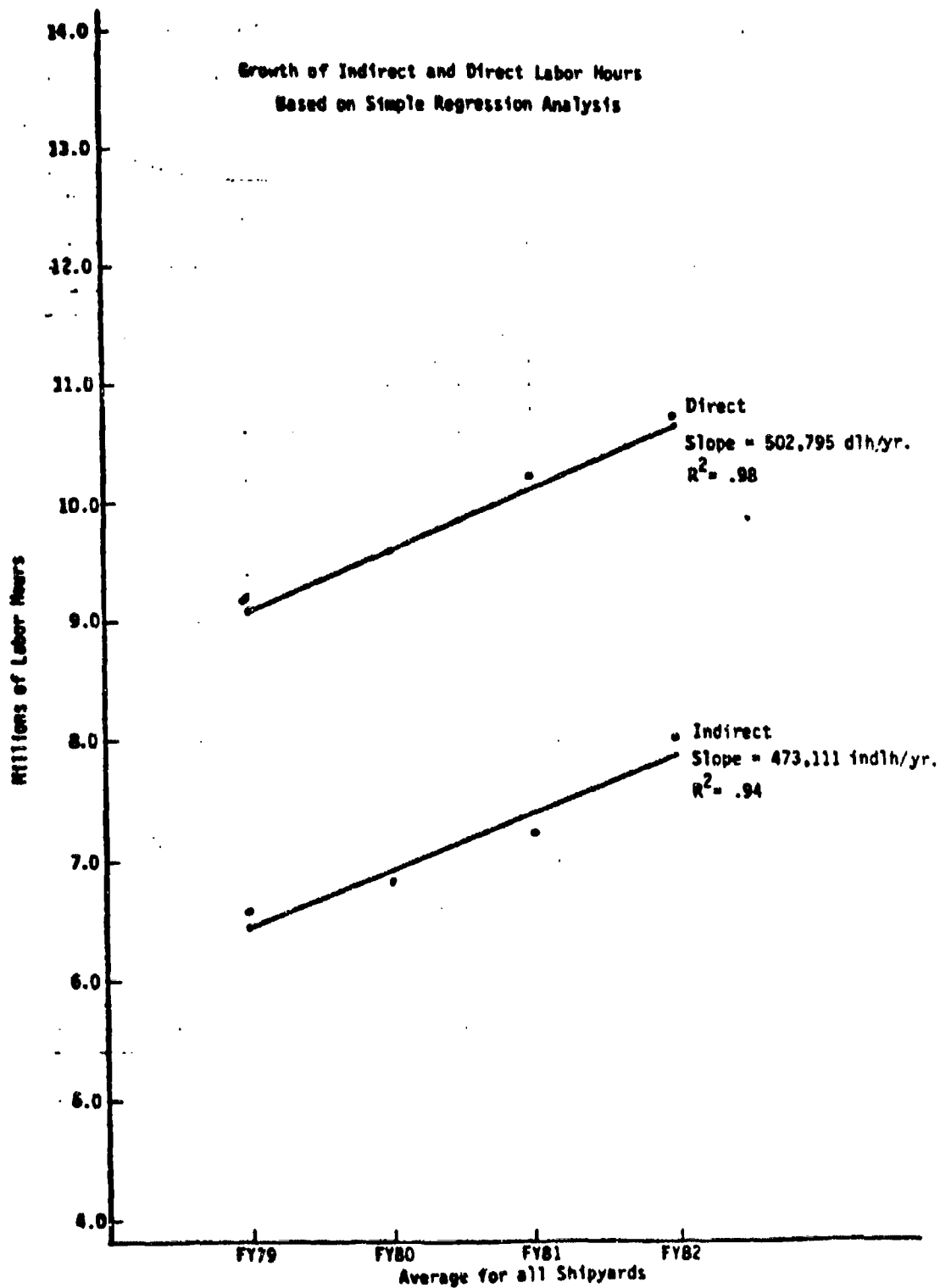


Figure 2-3

GROWTH OF INDIRECT AND DIRECT LABOR HOURS
BASED ON SIMPLE REGRESSION ANALYSIS



regression results, which are more fully described in Appendix A, indicate that, in total, direct labor hours grew slightly more than indirect labor hours. As Figure 2-3 illustrates, the average annual growth for all shipyards was 502,795 direct labor hours and 473,111 indirect labor hours. However, although direct labor hours are larger in absolute terms, indirect labor hours grew at a faster rate, (6.5% vs. 5%).

Furthermore, the regression analysis confirmed that indirect labor hours increased significantly faster than direct labor hours at four shipyards. The worst case was the Charleston shipyard where indirect hours increased almost 4 times more than direct hours, based on a comparison of the slopes computed in the regression equations. Similarly, indirect hours grew faster than direct labor hours by 268%, 31%, and 25% at Norfolk, Pearl Harbor, and Portsmouth, respectively.

Pinpointing the causes of the growth in indirect labor is difficult as there are many possible explanations, which are not adequately captured by the existing reporting structure used in the shipyard F&O statements. One explanation could be that the growth was artificially created because shipyards simply changed the way labor hours are reported and have shifted direct labor charges to indirect. Representatives from Charleston have suggested that some supervisory labor hours, which were previously charged to direct labor, were charged as indirect. Other contributing factors could be new training requirements necessitated by additional or new workload; greater effort spent on monitoring increased contract efforts; mandated programs; increased ship complexity; and increased planning needed to schedule SRAs and ERPs. Still another possible explanation is workload fluctuations that often require placing people on overhead functions while awaiting direct workload assignments.

To learn where the growth in indirect hours was occurring, we sub-categorized indirect labor hours by type of overhead: production and manufacturing, and G&A. Production and manufacturing labor hours accounted for approximately 77% of total indirect labor, with G&A indirect labor hours accounting for the balance. Manufacturing indirect labor hours increased most -- 26% over the four year period, followed closely by production indirect hours, which increased 25%. G&A indirect labor hours increased 15%. Not surprisingly, the increases in production and manufacturing indirect labor hours accounted for 75 percent of the total increase in indirect hours. Nevertheless, given the less variable nature of G&A costs, a 15% increase in G&A indirect labor hours may be considered excessive in light of a 17% increase in direct labor hours.

Workload Complexity and Planned Workload

Increasing ship complexity is a reason frequently used to explain the increasing costs of ship maintenance and modernization programs. More specifically, increasing ship complexity could be a major factor leading to growth in indirect hours because of the increased requirements for supervisory labor, training, and planning. To determine whether or not complexity was a significant factor for the increase in indirect labor hours, we examined the ratio of direct to indirect hours in the production work centers, by classifying work centers as Complex or Non-Complex. We also reviewed the complexity classifications of ships planned for overhaul or SRA.

The classification of production work centers is as follows:

Complex Work Centers

Inside Machine
Electrical
Electronics
Design
Non-Destructive Test
Radiological Control
Nuclear Inspection
Laboratory
Nuclear Engineering
Combat Systems
SSBN Project Office
Material Test

Non-Complex Work Centers

Shipfitter
Sheet Metal
Forge
Welding
Outside Machine
Boiler
Pipe
Woodworking
Paint
Riggers and Laborers
Non-Nuclear Inspection
Foundry

We expected that the results would show a decreasing ratio of direct to indirect labor in the complex shops (i.e., there would be fewer direct hours per indirect hour) and a steady or increasing ratio in the non-complex shops. However, the actual results showed that the ratio decreased in 66 percent of both the complex and non-complex shops. Not surprisingly, the four shipyards where indirect labor hours grew more than direct labor hours (Charleston, Norfolk, Pearl Harbor and Portsmouth) were prime examples of this phenomenon. At Charleston, for instance, the ratios increased in four complex work centers, but decreased in all other work centers. A complete discussion of this analysis and the ratios for each shipyard are presented in Appendix A.

While increases in indirect labor might be justifiable for the complex work centers, indirect labor should not be increasing faster than direct labor in the non-complex work centers. Navy shipyards have been performing the non-complex functions for a number of years. Granted that even the non-complex tasks may be getting somewhat more difficult, it is still improbable that increased complexity is a justifying factor for the significant growth in indirect labor hours.

We also tested for increasing workload complexity by grouping the ships planned for overhaul and SRA according to NAVSEA's ship complexity classifications, shown in Table 2-1. The results of this classification, displayed in

Table 2-2 are that fewer and less complex ships were planned for overhaul but more complex ships were planned for SRA work. Adjusting these results for the difference in magnitude between overhauls and SRA work, we could not substantiate increasing workload complexity.

Table 2-1
SHIP COMPLEXITY CLASSIFICATIONS

<u>Complex</u>	<u>Moderately Complex</u>	<u>Non-Complex</u>	
CV, CVN, AVT	DD-963	AD	AVM
SSBN, SSN, SS	FFG	AE	DD
CGN	AS	AFS	FF
CG	BB	AGO	LKA
DDG		AO	LPA
LHA		AOE	LPD
AGF		AR	LPH
ASR 21/22		ARS	LSD
LCC		ASR	LST
		ATF	MCM
		ATS	MSO
			PHM
		ALL OTHERS	

However, the decrease in planned overhauls between FY79 and FY82 raised the more fundamental question of whether the 19% increase in labor hours was supported by a commensurate increase in workload. The shipyard F&O statements are inadequate for analyzing this question since they do not contain the data required to compare direct planned and actual mandays on a functional work basis. Therefore, to determine whether workload had increased, we used the number of planned mandays for overhauls and non-nuclear alterations as a surrogate workload measure, assuming that planned mandays reflected the direct labor needed to accomplish the work.

In comparing planned mandays with actual direct labor hours, Long Beach and Philadelphia shipyards were excluded because these shipyards had extensive

Table 2-2

NUMBER AND COMPLEXITY OF PLANNED OVERHAULS AND SRAS

Overhauls	FY79			FY80			FY81			FY82		
	Complex	Moderate Complex	Non- Complex	Complex	Moderate Complex	Non- Complex	Complex	Moderate Complex	Non- Complex	Complex	Moderate Complex	Non- Complex
Portsmouth	2			2			2			2		
Philadelphia	5	1		2		1	3	1		3	2	
Norfolk	4		1	3	1	2	3		2	5		
Charleston	2		1	2	2		2	1		3	1	
Long Beach	4	1	2	5	1		2	3		3	3	1
Mare Island	4			3			3		1	3		
Puget Sound	4			4		1	4	1		3		1
Pearl Harbor	4		3	2		1	3		2	1		2
Total	29	2	7	23	6	5	22	6	5	23	6	4
SRAs												
Portsmouth	4			5			4			6		
Philadelphia												
Norfolk	5		1	9		3	14		4	15		
Charleston	4		2	6		1	6		2	10		
Long Beach							1NAV					
Mare Island	2			2			3		1NAV	4		
Puget Sound	4			3			3			1		
Pearl Harbor	2		2	5		2	7		6	6		
Total	21		5	30		6	38		13	42		



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workload (reactivation of the USS New Jersey and the Carrier Service Life Extension Program, respectively) not included in the surrogate measure of planned mandays. Excluding Philadelphia and Long Beach, planned mandays for overhauls and non-nuclear alterations, tabulated by induction year, decreased 2% from FY79 to FY82; direct labor hours for the six remaining shipyards increased 13%. Thus, although the planned mandays for repairs and non-nuclear alterations do not include all planned work and emergency and other unplanned work, as a surrogate measure of shipyard workload, they do not support the actual 13% increase in labor hours at six shipyards² These workload measures are shown and discussed in Appendix A.

Cost Implication of the Increase in Indirect Labor Hours

The cost implication of the faster growth in indirect labor hours is significant because indirect labor hours, particularly production and manufacturing indirect labor hours, are more expensive than direct labor hours. We quantified the effect of the faster growth in indirect hours by limiting indirect labor hour growth for all shipyards to the same rate of increase experienced by direct hours. Indirect hours increased at a slower rate than direct hours in FY80, but indirect hours grew faster than direct in FY81 and FY82. If indirect hours had grown at the same rate as direct hours in FY81 and FY82, the Navy would have saved \$63 million.

² If the mandays for the CV SLEP and New Jersey reactivation are added into the totals by induction years, planned mandays for all shipyards increase 4% while total direct labor hours increase 17%. However, this comparison does not reflect the significant workload increase at Philadelphia in FY81 caused by the induction of the U.S.S. Saratoga.

Labor Hour Summary

Labor hours increased 19% over the four year period. Most importantly, indirect labor hours grew faster than direct labor hours in total and at more than half of the individual shipyards. Most of this growth occurred in the production and manufacturing overhead areas, which have the most expensive hourly labor. Measures of workload complexity could not explain the faster growth in indirect hours. Finally, the increase in labor hours could not be supported by an increase in workload, based on an analysis using planned mandays as a surrogate workload measure. The shipyard F&O statements do not provide adequate data for measuring planned and actual workload at a functional level, or for determining the causes for the disproportionate increase in indirect labor.

Section 3

BEHAVIOR OF SHIPYARD COSTS

Introduction

Several Navy managers expressed concern that Navy shipyard costs are growing too rapidly, particularly in the overhead areas. To determine where excessive cost growth occurred, trend variations of direct and overhead costs between FY79 and FY82 for the eight shipyards were examined. These efforts focused on the components of direct and overhead costs such as labor, material, and contract costs. These costs were normalized by direct labor hours. We examined separately major components of overhead costs, namely, production, manufacturing, and general and administrative expense centers, as well as significant indirect program costs. Because of the importance of labor costs, a separate discussion on labor costs per labor hour is included.

Throughout the analysis, actual dollars expended were converted into constant FY84 dollars using OSD's indices for civilian pay, O&MN purchases, and fuel. Where possible, we used specific indices for specific cost elements. When a composite index was applied, it reflected the proportions of labor, purchases, and fuel experienced by shipyards as opposed to the OSD weighting of O&MN dollars. This is an important point because trends in real costs vary significantly, depending upon the inflation index applied. A more detailed explanation of the inflation indices used in conducting this analysis is provided in Appendix B.

An explanation of total costs is presented first followed by certain direct and overhead cost components. More detailed explanations including supporting

charts, graphs, sections on G&A expense centers, and other significant indirect costs are provided in Appendix B.

Total Costs

In FY82, Naval shipyards reported costs of \$3.4 billion, which was composed of \$2 billion for direct costs (59%) and \$1.4 billion for indirect costs (41%). Total costs for all shipyards, in actual dollars, increased \$1.2 billion or 55% between FY79 and FY82. Direct costs grew \$699 million, a 54% increase over FY79, and indirect costs grew \$510 million, a 57% increase.

The growth is less dramatic when expressed in constant dollars and in constant dollars per direct labor hour. In constant dollar terms, the growth rate was 22% for total costs. Constant dollar direct costs increased 23% while indirect costs grew 20%; while total direct costs grew faster than indirect costs, indirect costs grew as fast or faster than direct costs at five shipyards. When expressed in constant dollars per direct labor hour (DLH), total costs increased 4% over the four year period. Costs per direct labor hour only increased 4% because direct labor hours grew almost as fast as constant dollar costs over the four year period; average annual cost growth was 7.2% and average annual direct labor hour growth was 5.6%. Manday costs, in constant FY84 dollars, increased from \$322.64 in FY79 to \$336.40 in FY82.

By itself, a four percent increase in manday costs is not overwhelming, but it does indicate that real cost growth occurred. However, this is not the ultimate measure of shipyard efficiency. Real shipyard efficiency cannot be evaluated because data is only available on costs per unit of input (i.e., labor hours or manday) and input data cannot be related to specific workload outputs. As previously discussed we could not determine if increases in labor hours were justified by commensurate increases in shipyard workload using the F&O state-

ments. Thus, in addition to the four percent cost growth, shipyard efficiency may have actually decreased because more labor hours were expended on the same (or a smaller) level of workload.

Nevertheless, as a measure of input, costs per DLH do allow comparisons among shipyards. Figure 3-1, Figure 3-2, and Appendix B Table B-4 illustrate both the direct and indirect costs per DLH for each shipyard. For the period FY79-82, the non-nuclear shipyards, Long Beach and Philadelphia, had the highest direct costs per DLH, while Portsmouth consistently had the lowest. Puget Sound had the lowest indirect costs per DLH and was the only shipyard that did not experience an increase in FY82. As displayed in Appendix B, Table B-5, decreases in both direct and indirect costs per DLH occurred only at Mare Island; Portsmouth, and Charleston had the largest percentage growth in total costs per DLH.

Direct Costs by Labor, Material, Contractual, and Other

In FY82, direct costs at all shipyards were composed of 62% labor, 27% material, 9% contractual, and 2% other. Table B-6 in Appendix B lists the constant dollar components of direct costs for each shipyard.

Over the four year period, contractual costs had the largest growth, increasing by 52% in constant dollars. Although contract costs rose at all but one shipyard between FY79 and FY82, 32% of the cost growth occurred at Philadelphia alone. The relatively large percentage of direct contract expenses at the non-nuclear yards may help to explain the high direct cost per DLH at Long Beach and Philadelphia i.e., if work is contracted for, there are fewer direct labor hours over which to spread the costs. Constant dollar, direct material costs increased 35% over four years and the largest yearly increase in material costs was between FY81 and FY82. Since FY82 was the first year that depot level

Figure 3-1

DIRECT COSTS PER DIRECT LABOR HOUR
(Constant FY84 Dollars)

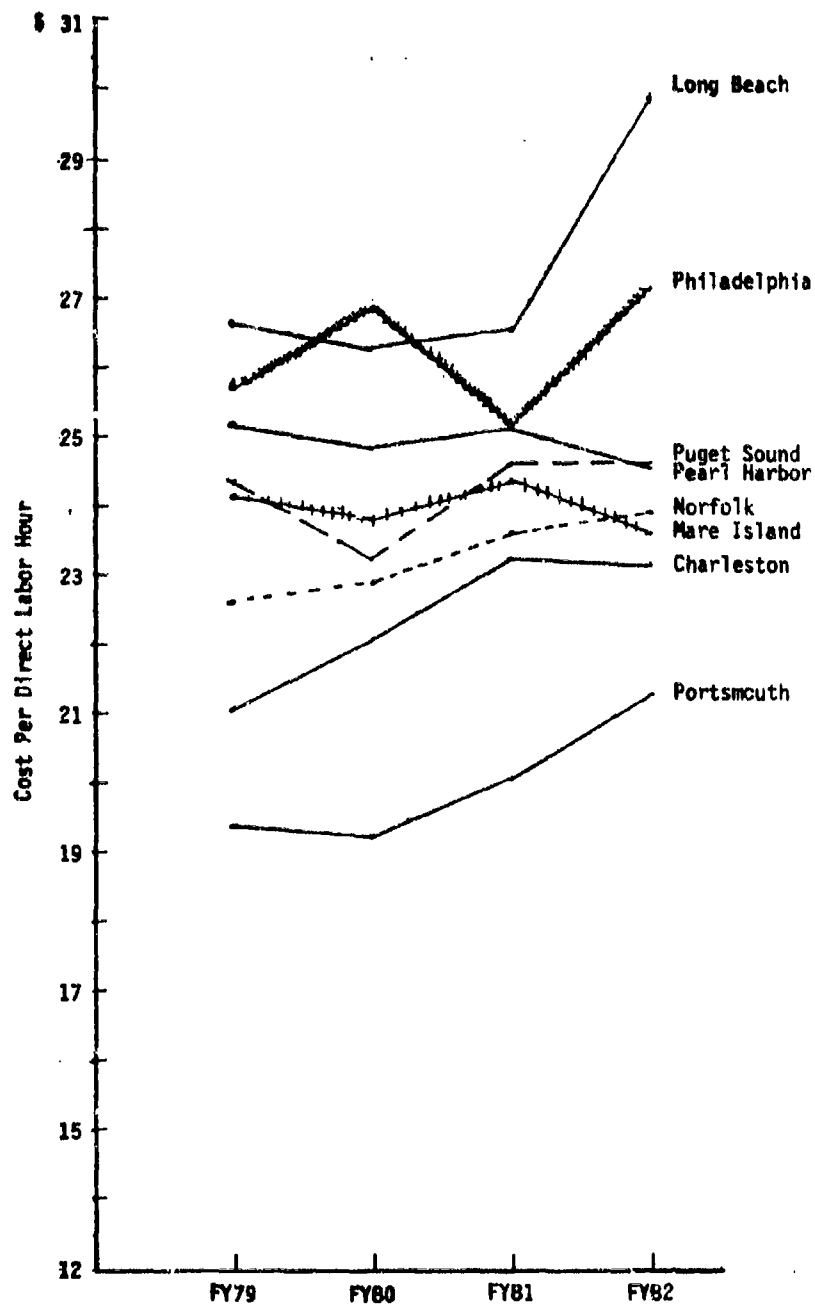
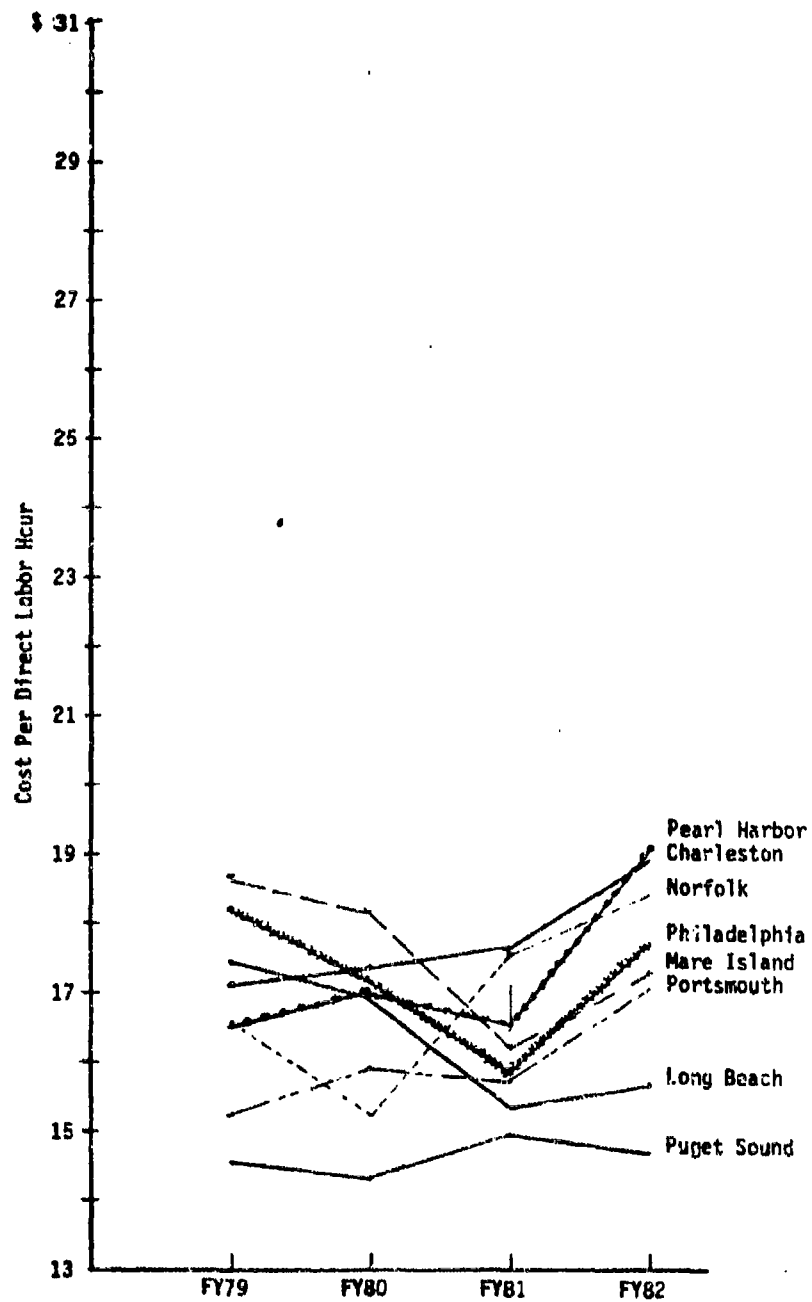


Figure 3-2

INDIRECT COSTS PER DIRECT LABOR HOUR
(Constant FY84 Dollars)



reparable material was stock funded rather than directly appropriated, 19% constant dollar growth in direct material for all shipyards was not unexpected in that one year. However it is interesting to note that not all individual shipyards had the highest yearly percentage increase in FY82, in spite of this funding change.

Constant dollar labor costs only increased 16% during the four years. Despite the fact that contract and material costs each increased at faster rates, labor was the largest cost component and accounted for 44% of the increase in direct costs.

Labor Costs Per Hour

Because labor costs were the largest component of both direct and indirect costs and accounted for most of the actual cost increases, they were examined in more detail. Specifically, the constant dollar labor cost per labor hour was computed for direct, indirect and the production and manufacturing component of indirect. These rates are displayed by shipyard in Table 3-1. In total, indirect labor hours were slightly more expensive than direct labor hours, but that relationship was not consistent for each shipyard. One of the most significant observations portrayed is that for each shipyard in each year, the most expensive labor hours were indirect production and manufacturing. As discussed in Section 2, these types of labor hours also had the largest rate of growth. This faster increase in the more expensive indirect hours, especially production and manufacturing hours, contributed to rising shipyard costs.

Three quarters of the constant dollar labor hour rates shown in Table 3-1 declined between FY79 and FY82 even though in actual dollars they increased. The most probable explanation for this is that the shipyards have a less skilled or less experienced workforce because of attrition and new hires. This observa-

Table 3-1

LABOR COSTS PER HOUR
TOTAL DIRECT, PRODUCTION AND MANUFACTURING INDIRECT, TOTAL INDIRECT

	Constant FY79	Dollar FY80	Labor FY81	Costs Per Hour FY82
Norfolk				
Total Direct	\$12.88	\$13.01	\$13.19	\$13.17
Production & Manufacturing Indirect	13.52	14.66	13.97	13.92
Total Indirect	12.73	13.60	13.49	13.13
Puget Sound				
Total Direct	\$15.79	\$15.68	\$15.64	\$15.72
Production & Manufacturing Indirect	17.03	17.00	16.99	16.84
Total Indirect	15.80	15.99	15.91	15.71
Philadelphia				
Total Direct	\$14.71	\$14.39	\$13.92	\$14.07
Production & Manufacturing Indirect	15.70	15.36	15.23	15.23
Total Indirect	14.31	14.34	14.33	14.31
Mare Island				
Total Direct	\$17.57	\$17.49	\$17.18	\$16.74
Production & Manufacturing Indirect	18.85	18.77	18.78	18.40
Total Indirect	17.59	17.66	17.04	16.62
Portsmouth				
Total Direct	\$13.42	\$13.62	\$13.70	\$13.55
Production & Manufacturing Indirect	14.77	14.96	15.05	14.78
Total Indirect	13.98	14.15	14.27	14.03
Long Beach				
Total Direct	\$15.40	\$15.40	\$15.35	\$15.26
Production & Manufacturing Indirect	16.90	16.57	16.76	16.63
Total Indirect	15.65	15.68	15.89	15.67

Table 3-1 continued

Labor Costs Per Hour
Total Direct, Production and Manufacturing Indirect, Total Indirect

	Constant FY79	Dollar FY80	Labor Costs FY81	Per Hour FY82
Charleston				
Total Direct	\$14.54	\$14.83	\$14.85	\$14.86
Production & Manufacturing Indirect	15.73	15.97	15.79	15.60
Total Indirect	14.92	15.28	15.08	14.89
Pearl Harbor				
Total Direct	\$17.26	\$17.22	\$16.90	\$16.91
Production & Manufacturing Indirect	19.22	18.90	18.61	18.48
Total Indirect	17.56	17.74	17.36	17.42
Total				
Direct	\$15.08	\$15.09	\$14.99	\$14.96*
Production & Manufacturing Indirect	16.24	16.44	16.22	16.08*
Indirect	15.11	15.41	15.24	15.03*

* The actual dollar counterparts of these constant dollar costs are \$14.32 Direct, \$15.39 Production and Manufacturing Indirect, and \$14.38 Indirect.

tion is supported by the fact that direct labor unit costs decreased most at Philadelphia and Mare Island, which had the largest increases in direct labor hours.

Indirect Costs

The major emphasis of our cost analysis was placed on indirect or overhead costs because overhead costs are viewed as discretionary and many Navy people feel that these costs are increasing excessively. Essentially, overhead costs at Navy shipyards include all supervisors, base operating costs, general and administrative costs, planning, quality control, testing, and training. In what follows, indirect cost growth is examined by labor, material, contractual and other; type of overhead; and significant programs.

Indirect Costs by Labor, Material, Contractual and Other

Over the four years studied, indirect cost composition ranged between 66-69% labor, 7-9% material, and 22-26% contract and other. In FY82, unadjusted indirect costs at all shipyards were \$1.4 billion: \$923 million labor, \$362 million contract and other, and \$121 million material. Constant dollar costs for these components are shown by individual shipyard in Appendix B, Table B-7. In constant dollars, the fastest growing indirect components were labor and contractual and other. Each grew 21% between FY79 and FY82, while material grew 14%. Purchased utilities, which increased 30%, was a significant part of the contract and other category. The labor portion of indirect costs, accounted for 67% of constant dollar cost growth.

Indirect Costs by Production, Manufacturing, and General and Administrative

Navy shipyards have three types of overhead costs: production, manufacturing and G&A. The production category includes numerous production shops actually performing the shipwork, other production cost centers such as design, testing, inspection, combat systems and nuclear engineering, and quasi production functions like family housing, PERA and repairables rework. Manufacturing overhead is made up of planning, the central tool room, quality assurance and general production. G&A indirect costs include public works, controller, supply, data processing, shipyard general and industrial relations. The cost growth and distribution discussed in this section are the overhead costs recorded in these three categories after reimbursements were deducted and after power costs were transferred from G&A to the production and manufacturing expense centers.

In FY82, 40% of all shipyard indirect costs were in production, 28% were manufacturing and 32% were general and administrative. These percentages equate to \$535 million, \$383 million, and \$423 million in actual FY82 dollars respectively. Conversion to constant dollar overhead costs and their percentage growth by activity from FY79 to FY82 is contained in Table B-8 in Appendix B. Manufacturing had the fastest rate of growth for all the shipyards between FY79 and FY82, 30% in constant dollars. A large amount of power costs were charged to manufacturing overhead; in fact power transfers accounted for 35% of the constant dollar increase in all manufacturing costs. However, when power transfer costs were deducted, constant dollar manufacturing costs still increased 24% versus production's 20% rise and G&A's 13% rise. The magnitude of the increase in manufacturing overhead is attributable to rising utility costs and to large growth in, the relatively expensive, manufacturing labor hours.

Many Navy observers seemed to feel that G&A expenses were discretionary and were growing out of control. The facts, however, show that the G&A component experienced the smallest rate of growth -- only 13% over the four years. The G&A component contains many of the overhead functions that are considered to be the "fixed" costs of doing business (e.g. controller's shop, shipyard CO); consequently, G&A costs are not expected to show great fluctuation on an annual basis. As expected, constant dollar G&A expenses were more steady over time than the production oriented components. Nevertheless, there are elements of G&A that are discretionary, and since total direct costs increased only 23%, a 13% increase in indirect G&A is substantial and suggests potential for cost savings.

Indirect costs are charged to direct labor hours via two overhead rates; "production" and "general and administrative". The production rate includes production and manufacturing overhead costs divided by direct production hours, and is applied only to direct production hours. The G&A rate is applied to all direct labor hours. Between FY79 and FY82, in constant dollars, the combined production overhead rate for all shipyards increased 6%; the G&A overhead rate decreased 3%. Graphs of the constant dollar production and G&A rates for each shipyard are shown in Appendix B.

Non-nuclear yards had the lowest production overhead rates and Puget Sound had the lowest and most steady G&A rate. We expected the production overhead rates to follow direct labor hour trends and thus remain fairly stable over time. Similarly, G&A rates were expected to vary inversely with direct labor hours, since relatively fixed G&A costs spread over more labor hours would result in falling rates. The expected behavior patterns of the production and G&A rates did not occur and the rates and growth patterns varied disproportionately. Appendix B provides a more detailed description of these rates.

Indirect Significant Program Costs

Eight of the nineteen indirect program costs reported in the Financial and Operating Statements are analyzed in this section. These eight programs, which included non-supervisory labor (graded and ungraded), and supervisory labor (graded and ungraded), purchased utilities, training, recurring maintenance, and major non-recurring maintenance (MNRM) composed about 78% of total indirect costs. A more detailed discussion of each program area and the escalation index applied to each is provided in Appendix B. Total constant dollar costs and costs per DLH for these shipyard programs are displayed in Table 3-2.

The largest program categories experienced the least growth. Supervisory and non-supervisory labor, which are the largest categories and represent two thirds of indirect labor costs, had growth rates of 22%, one percent more than total indirect labor growth. Recurring maintenance, the next largest program, had 13% growth over the four years; costs per DLH declined 4%. Purchased utilities, training, and MNRM programs all had four-year constant dollar growth rates of at least 30%. While maintenance accruals accounted for approximately one-third of the constant dollar MNRM growth, NIF activities were also permitted to raise their customer maintenance charges for one of the study years in an effort to reduce Backlog of Maintenance and Repair (BMAR). This one year policy probably contributed to the four year cost growth in major maintenance. The large increase in training costs could be explained by changes in anticipated workload, a lower skilled labor force, or idle time. We were told that Norfolk specifically incurred training costs to prepare for a larger nuclear workload, but there was insufficient information available to assess whether that reason justifies Norfolk's 29% constant dollar increase.

Table 3-2

**INDIRECT, SIGNIFICANT PROGRAM COSTS FOR ALL SHIPYARDS
(Constant FY84 \$)**

Program	FY79	FY80	FY81	FY82	% Increase FY79-FY82
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(\$000)

Constant Dollar Costs

Non-Supervisory Labor	270,386	279,283	302,940	330,456	22%
Supervisory Labor	251,209	265,003	278,031	305,916	22%
Purchased Utilities	94,944	95,610	114,058	123,572	30%
Training	71,497	74,036	84,709	103,147	44%
Recurring Maintenance	175,532	174,664	171,109	197,555	13%
Major Non-Recurring Maintenance (MNRM)	71,827	74,470	83,472	101,467	41%

Constant Dollar Costs/DLH

Non-Supervisory Labor	\$3.66	\$3.62	\$3.77	\$3.84	5%
Supervisory Labor	3.40	3.43	3.46	3.55	4%
Purchased Utilities	1.29	1.24	1.42	1.43	11%
Training	.97	.96	1.05	1.20	24%
Recurring Maintenance	2.38	2.26	2.13	2.29	-4%
Major Non-Recurring Maintenance (MNRM)	.97	.97	1.04	1.18	22%

Costs Reported in Financial and Operating Statements Exhibit C, Significant Program Cost Summary.

Cost Summary

Unadjusted Navy shipyard costs increased 55% or \$1.2 billion between FY79 and FY82. When these costs were adjusted for inflation and normalized by the number of direct labor hours, real expenses on a per labor hour basis increased only 4%. Indirect costs grew faster than or equal to direct costs at five individual shipyards. The largest indirect cost increases occurred in the production and manufacturing areas. Costs there rose 24% while G&A costs rose 13%. Other overhead costs with significant percentage growth were utilities, MNRM, and training. Labor continues to be the most significant cost component, even though material and contractual costs increased at a faster rate than labor costs. Labor costs per hour for the combined shipyards declined on an inflation adjusted basis.

Section 4

SUMMARY AND RECOMMENDATIONS

The objectives of this study are to determine if and where growth in Navy shipyard costs has occurred between FY79 and FY82 and if the growth was justified. Total costs for all shipyards, in unadjusted dollars, increased \$1.2 billion or 55% between FY79 and FY82. In constant dollar (inflation-corrected) terms, growth rates were 22% for total costs; direct costs increased 23% while indirect costs grew 20%. For the same time period total shipyard labor hours increased from 126.5 million to 150.3 million, an increase of 23.8 million hours, or 19%. Direct hours increased by 17% and indirect by 22%. When expressed in constant dollars per direct labor hour, total unit costs increased 4% over the four year period. Thus, we conclude that real cost growth of 4% in mandays rates occurred.

However, this initial finding is inconclusive in ultimately evaluating shipyard efficiency. Overall shipyard efficiency is ideally measured by evaluating the unit costs of input (e.g., labor hours, material, etc.) needed to produce specific, comparable outputs. The unit costs of input, labor hours, have increased by four percent but an even more serious question is raised by the increase in labor hours. The fundamental issue is whether or not the increased number of labor hours produced commensurate increases in quantities and quality of shipyard output.

Indeed, in a recent CNO Memorandum to Commanders in Chief of Atlantic and Pacific Fleets and to Chief of Navy Material, the CNO expressed great concern

about this issue, specifically, the recent increase in submarine overhaul costs, durations, and mandays. To quote a portion of this memorandum.³

"The trend of increased man-days, increased costs well beyond the inflation rate, and longer durations for submarine overhauls cannot be allowed to continue. It is difficult enough to contend with the effects of inflation. When inflation is compounded by increased man-days, whether caused by larger work packages, poor productivity or additional technical or administrative requirements, our plans for building and operating an expanded submarine force are placed in jeopardy."

At the present time, it is not possible to link objective measures of shipyard output to labor and cost data contained in the shipyard Financial and Operating (F&O) Statements. This inability arises because output measures, such as overhauls, are expressed on an induction basis. On the other hand, in F&O statements -- both money and hours -- are accounted for on accrual basis as the work is performed.

For this reason, it was not possible to analyze the "labor-to-output" problem. Instead, the analysis proceeded using various surrogates for output such as workload complexity and aggregate planned (budget) manday workload. These surrogates, however, were inconclusive with respect to the question of whether or not shipyard labor growth was justified.

Included in our attempts to analyze growth in costs was an analysis of the relationship between indirect and direct labor hours and costs. The findings show that indirect labor hours grew at a faster rate than direct labor hours. The cost implications of this faster growth are significant because indirect labor hours, particularly production and manufacturing labor hours, (which

³ CNO Memo Serial 00/3U300192 of 23 May, 1983.

experienced the faster growth), are more expensive than direct labor hours. This unexpected growth may imply that adequate controls are not being exercised in this area of shipyard operations. Again, the data presented in the shipyard F&O statements is insufficient for determining the underlying causes and justification for this growth.

To improve the management of shipyard operations, an aspect of which includes the ability to perform the kinds of analyses undertaken in this report, several fundamental changes in shipyard management practice should be considered:

- o Develop Shipyard Output Measures. The Navy presently measures output in terms of the number of overhauls and RA/TAs, total costs, and direct labor mandays. More refined output measures are needed, with a functional orientation. To recommend that output measures be implemented is easy, but the implementation of such measures will be a difficult, evolutionary process because shipyard workload is diverse and reflects a job shop orientation rather than a production line.

However, there are some indications that output measures can be developed. First, Navy planners have been estimating workload requirements based on work packages for years, and some standards do exist. While these estimates may be imperfect, they can serve as an initial reference point for developing output measures. Second, shipyard representatives have indicated that approximately 80% of a submarine overhaul is fairly standardized, although there are differences in ship's equipment configuration. This suggests that macro level standards can be developed with allowances built in for work package differences. It further suggests that some significant portion of other shiptype work packages (e.g. DDG, CG, etc) may also be standardized. Third, representatives in Charleston Naval Shipyard are attempting to develop work standards for the amount of mandays required to do specific jobs. These people are familiar with the difficulties in workload planning and the fact that they are attempting to develop standards suggests that the concept is feasible.

- o Establish a Policy to Control Shipyard Indirect Hours. While it is clear that the indirect labor hours are growing rapidly, particularly in the areas of production and manufacturing, the underlying causes for this growth cannot be determined using the data presented in the shipyard F&O statements. Currently, indirect labor hours are reported against cost classifications.

Many of these classifications (e.g., supervisory and non-supervisory labor) have an "element of expense" orientation and are not useful for determining the functional purposes for which indirect hours are incurred. The first step to control indirect labor hour growth is to conduct an analysis which identifies the functional reasons for incurring indirect hours. Once the factors contributing to indirect hour growth are identified, several policy options can be considered. One option that may be useful is to re-align the reporting structure so that all labor hours which can be directly related to specific customers are charged to direct labor. This option will reduce the large, ambiguous cost classifications for supervisory and non-supervisory labor and will enable the shipyards to bill customers more accurately for real costs incurred. Another option may be to limit indirect growth in specific areas or to limit overall indirect growth to a prescribed function of direct hours or to previous years' indirect costs. The implementation of this option should be structured to avoid a simple arbitrary shifting of indirect hour to direct hour charges. Regardless of the option selected, the cost classification structure should be revised to reflect more accurately the functional purpose for indirect labor hour charges.

- o Develop an Improved Financial Management Report for Shipyards. This report would be aimed at managers at OPNAV and NAVSEA levels. It would organize, convert and add new data to the existing shipyard Financial and Operating (F&O) Statements. This report would express shipyard performance in terms familiar to Navy program managers. The report will display a breakdown of significant categories of shipwork. (Possible consideration is along the lines of the Ship Departure Reports.) Data provided along the same work structure would show both hours and costs by direct and indirect. It would show the percentage completion and identify any variances from plan. We understand that this detail is available in each shipyard's management system. Our suggestion is intended to better integrate fiscal data with program information to produce a clearer picture of shipyard operations.

Appendix A

BACK-UP DISCUSSION FOR LABOR HOUR TRENDS

This appendix presents more of the detailed data used in arriving at the conclusions on labor hour trends. The following materials are discussed:

- o Direct and indirect labor hours by shipyard for FY79-82;
- o Regression results which show the growth in direct and indirect labor hours by year for each shipyard;
- o Ratios of direct to indirect labor for complex and non-complex production work centers; and,
- o The number of planned mandays for each shipyard for each fiscal year.

Each of these materials will be discussed briefly in turn.

Direct and Indirect Labor Hours

Table A-1 shows the number of direct labor hours incurred at each shipyard from FY79-FY82. Norfolk and Puget Sound consistently had the largest number of direct labor hours, while Pearl Harbor always had the least amount. As the table indicates, total direct labor hours increased 17% from FY79 to FY82. Direct labor hours increased at all shipyards with Philadelphia experiencing the largest increase, 41%. Charleston had the least growth, 4% over the four year period. As this data and the graph in Section 2 illustrate, the number of direct labor hours varies annually at certain shipyards. Charleston is the best example; the number of hours actually peaked in FY80, dropped 4% to FY79 levels in FY81 and rose close to the FY80 level again in FY82.

Table A-1
DIRECT LABOR HOURS

	FY79	FY80	FY81	FY82	% Increase FY79-FY82
Norfolk	12,715,171	13,205,396	12,786,134	13,686,492	8%
Puget Sound	11,914,585	12,854,626	12,364,376	13,461,349	13%
Philadelphia	8,907,315	9,685,686	11,993,538	12,588,022	41%
Mare Island	9,354,585	9,588,265	10,677,776	11,747,547	26%
Portsmouth	8,143,348	8,422,894	8,711,005	9,103,546	12%
Long Beach	7,696,970	7,495,250	8,280,003	8,948,953	16%
Charleston	8,235,514	8,619,548	8,253,387	8,591,957	4%
Pearl Harbor	6,819,352	7,276,019	7,321,972	7,986,663	17%
Total	73,786,840	77,147,684	80,388,191	86,114,529	17%
Average	9,223,355	9,643,460	10,048,523	10,764,316	

From Financial and Operating Statements, Exhibit H-1, Summary of Labor Hours.

Table A-2 lists the total indirect labor hours incurred at each shipyard in FY79-82; the indirect labor hours are further broken down by type of overhead - production and manufacturing and general and administrative. Again Norfolk and Puget Sound consistently had the highest number of indirect labor hours. Pearl Harbor had the fewest indirect hours in FY79-81, but in FY82 Long Beach had the least number of indirect labor hours. In light of the 16% increase in direct labor hours at Long Beach, the 9% increase in indirect hours is fairly minimal and suggests that Long Beach might have changed its accounting practices in charging direct and indirect labor hours or that the shipyard was previously operating below capacity.

Indirect labor hours increased at all shipyards, with Philadelphia and Pearl Harbor increasing the most, 49% and 33%, respectively. In terms of simple four year percentage increases from FY79 to FY82, indirect labor hours grew faster than direct labor hours at five shipyards - Pearl Harbor, Norfolk, Portsmouth, Charleston and Philadelphia. Direct labor hours grew faster than indirect hours at Long Beach and Mare Island, and they grew at the same rate at Puget Sound. As will be discussed shortly, the regression results differ from the four-year percentage increases because the regressions are affected by the rate of annual change rather than the total overall change.

Table A-2 also illustrates the point that the most significant growth in indirect hours occurred in the production and manufacturing overhead areas. Within the indirect area, production and manufacturing hours increased 26%, from 33.7 million in FY79 to 42.3 million in FY82, while G&A hours increased 15% from 19.0 million in FY79 to 21.9 million in FY82. Increases in production and manufacturing indirect labor hours accounted for 75 percent of the total increase in indirect hours.

Table A-2
INDIRECT LABOR HOURS

	FY79	FY80	FY81	FY82	% Increase FY79-FY82
<u>Total</u>					
Norfolk	9,884,370	9,622,629	10,495,778	11,828,101	20%
Puget Sound	8,250,248	8,668,554	8,864,972	9,340,618	13%
Philadelphia	5,924,324	6,735,263	7,716,412	8,833,143	49%
Mare Island	6,898,545	6,960,635	7,199,553	8,568,666	24%
Portsmouth	6,193,670	6,303,499	6,657,612	7,394,044	19%
Long Beach	4,973,927	5,142,343	5,250,324	5,401,382	9%
Charleston	6,229,935	6,341,008	6,716,374	7,018,165	13%
Pearl Harbor	4,349,132	4,783,335	5,080,561	5,795,183	33%
	52,704,151	54,557,266	57,981,586	64,179,301	22%
<u>Production and Manufacturing</u>					
Norfolk	6,361,693	6,002,548	6,755,863	7,647,426	20%
Puget Sound	5,544,406	5,817,936	5,844,234	6,278,159	13%
Philadelphia	3,273,939	3,813,250	4,531,588	5,500,874	68%
Mare Island	4,620,443	4,735,340	4,763,257	5,738,862	24%
Portsmouth	4,119,704	4,198,368	4,465,924	5,082,030	23%
Long Beach	2,893,070	3,085,400	3,156,545	3,266,512	13%
Charleston	3,934,134	4,075,571	4,241,091	4,544,825	16%
Pearl Harbor	2,921,934	3,333,091	3,552,164	4,203,099	44%
	33,669,323	35,061,504	37,310,666	42,261,787	26%
<u>General and Administrative</u>					
Norfolk	3,522,677	3,620,081	3,739,915	4,180,675	19%
Puget Sound	2,705,842	2,850,618	3,020,738	3,062,458	13%
Philadelphia	2,650,385	2,922,013	3,184,824	3,332,269	26%
Mare Island	2,278,102	2,225,295	2,436,296	2,829,804	24%
Portsmouth	2,073,966	2,105,131	2,191,688	2,312,014	11%
Long Beach	2,080,857	2,056,943	2,093,779	2,134,870	3%
Charleston	2,295,801	2,265,437	2,475,283	2,473,340	8%
Pearl Harbor	1,427,198	1,450,244	1,528,397	1,592,084	12%
	19,034,828	19,495,762	20,670,920	21,917,514	15%

From Financial and Operating Statements, Exhibit H-1, Summary of Labor Hours.

During discussions with representatives from Charleston Naval Shipyard, some of the expense centers with large increases in production and manufacturing indirect hours at Charleston were further isolated. It appears that over half of the growth in indirect hours was attributable to the Production Department and the Planning Shop. Indirect hours in the Production Department increased 54% from 452,401 in FY79 to 700,959 in FY82; similarly, indirect hours increased 20% in the Planning Shop (406,725 in FY79 to 488,440 in FY82). For the most part, the tremendous growth in indirect hours in these shops cannot be fully explained, although Charleston is (and has been) engaged in developing more workload standardization, an effort which requires production and planning personnel.

A similar analysis of the Production department and Planning shops at Norfolk, Philadelphia, Pearl Harbor and Portsmouth did not yield the dramatic results discovered at Charleston. Nevertheless, indirect labor hour growth in these departments was still significant and accounted for 14.9%, 15.7%, 22.3%, and 24.6% of the total growth in production and manufacturing indirect hours at Norfolk, Philadelphia, Pearl Harbor, and Portsmouth respectively. This suggests that activities performed in the Production departments and Planning shops should be further assessed at these shipyards to explain why such significant growth occurred.

Regression Results

As discussed in Section 2, we performed an ordinary least-squares regression of direct and indirect labor hours against time for each shipyard; Figures A-1 thru A-8 show the results of the analysis.

Figures A-1 thru A-4, which are for Charleston, Norfolk, Portsmouth, and Pearl Harbor, respectively, all indicate that indirect labor hours were growing

faster than direct labor hours. The worst case was Charleston where indirect labor hours increased 274,006 per year while direct labor hours only increased by 70,316 hours per year. Since there are more direct labor hours than indirect hours, a greater increase in the absolute number of indirect hours clearly indicates that indirect hours are growing at a faster rate than direct hours at these shipyards. In Graphs A-5 thru A-8 (Long Beach, Mare Island, Philadelphia, and Puget Sound), direct labor hours increased more than indirect hours. At Long Beach and Mare Island, direct labor hours grew at a faster rate than indirect hours. However, at Philadelphia and Puget Sound indirect labor hours grew at faster rate than direct hours, even though direct hours increased more. Thus, the regression analysis further substantiates the fact that indirect hours are growing at a faster rate than direct hours.

Ratios of Direct to Indirect Labor Hours for Complex and Non-Complex Production Centers

As discussed in Section 2, the ratios of direct labor to indirect labor in FY79 and in FY82 were computed for all production work centers, which were categorized as complex or non-complex; the change in ratios from FY79 to FY82 was then evaluated. Tables A-3 thru A-10 show the results of this analysis. The expected results were that the ratios would decrease (i.e., fewer direct labor hours per indirect labor hour) in the complex production shops and would stay the same or increase in the non-complex production centers. The actual results were that the ratios decreased in two-thirds of both the complex and non-complex shops, but the results varied by shipyard.

At Charleston and Pearl Harbor, the direct to indirect labor hour ratios increased at four complex shops and decreased at all other sixteen shops. Ra-

tios increased in five complex shops and in one non-complex shop at Norfolk, with the remaining sixteen shops showing decreases. Similar results were obtained for Philadelphia and Portsmouth. Not surprisingly, all five of these shipyards have experienced faster growth in indirect labor hours than in direct hours.

Results for Long Beach, Mare Island, and Puget Sound differed from those discussed above. At Long Beach, the direct to indirect ratios increased in all but one of the non-complex shops and in four of eight complex shops. Eight of twelve non-complex ratios increased at Puget Sound and six of twelve increased at Mare Island; both shipyards experienced increased ratios in at least three complex shops as well. The increase in ratios is not surprising for these shipyards because of the fact that direct labor hours grew faster than indirect labor hours at these facilities.

One final observation on these production workshop ratios is that, on the whole, the number of direct labor hours charged per indirect labor hour seems relatively small (i.e., the direct labor support base for the indirect work force seems fairly small). The largest ratio in any shop in either FY79 or FY82 was 7.30 (7.3 direct hours per indirect hour) and most ratios were well below that. The normal range of ratios appears to be 0.7 to 5.0; this means that the shipyards were charging the customers for one indirect production hour per 0.7 to 5.0 direct production hours charged. This has to have a significant effect on shipyard overhead.

Number of Planned Mandays

Table A-11 illustrates the number of planned mandays for ship repair and non-nuclear alterations for FY79-FY82. This set of data was assembled from information used in preparing the Congressional O&MN budget submission. The

planned workload for the ship repair and alteration program declined 3% between FY79 and FY82. These planning numbers do not include the mandays for major ship conversions and battleship reactivations. Adding manday estimates for the reactivation of the New Jersey at Long Beach and the carrier service-life extension program at Philadelphia to these figures causes planned workload on a induction year basis to increase by about 4%.

Table A-11 shows that planned mandays fluctuate annually at each shipyard. This is because the planned mandays are for inductions in a given fiscal year, and all mandays are not actually incurred in the fiscal year in which the ship is inducted. Because of these fluctuations planned mandays may not be a reliable indication of yearly changes in the amount of individual shipyard workload, but they do indicate the volume of the overall program. Furthermore, they reflect the mandays on which customer rates are based. The shipyard F&O statements should show planned workload by fiscal year, so actual performance can be better measured and related to costs. That information would help shipyard managers to determine if mandays were efficiently incurred.

Figure A-2
Growth of Indirect and Direct Labor Hours
Based on Simple Regression Analysis

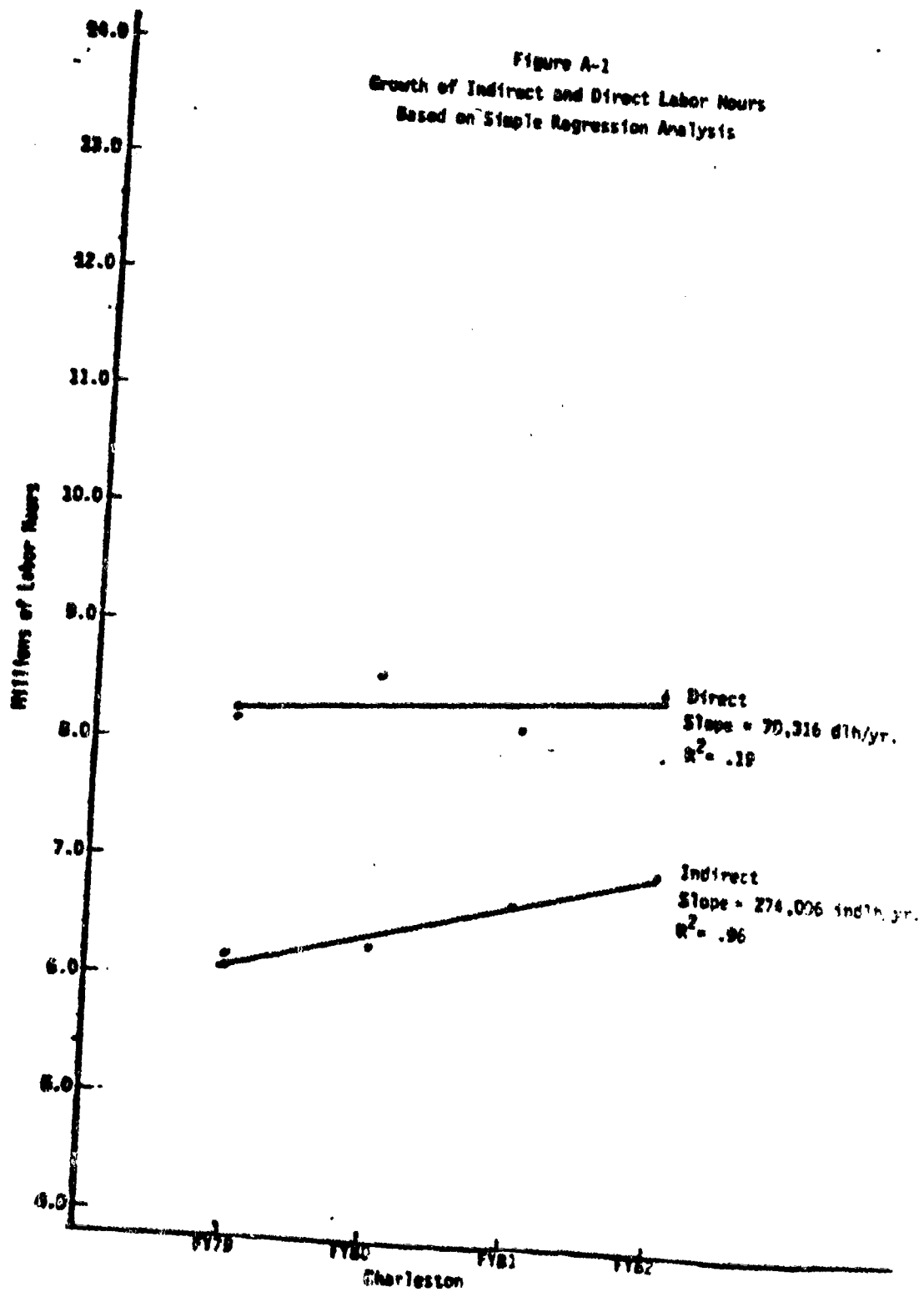


Figure A-2
Growth of Indirect and Direct Labor Hours
Based on Simple Regression Analysis

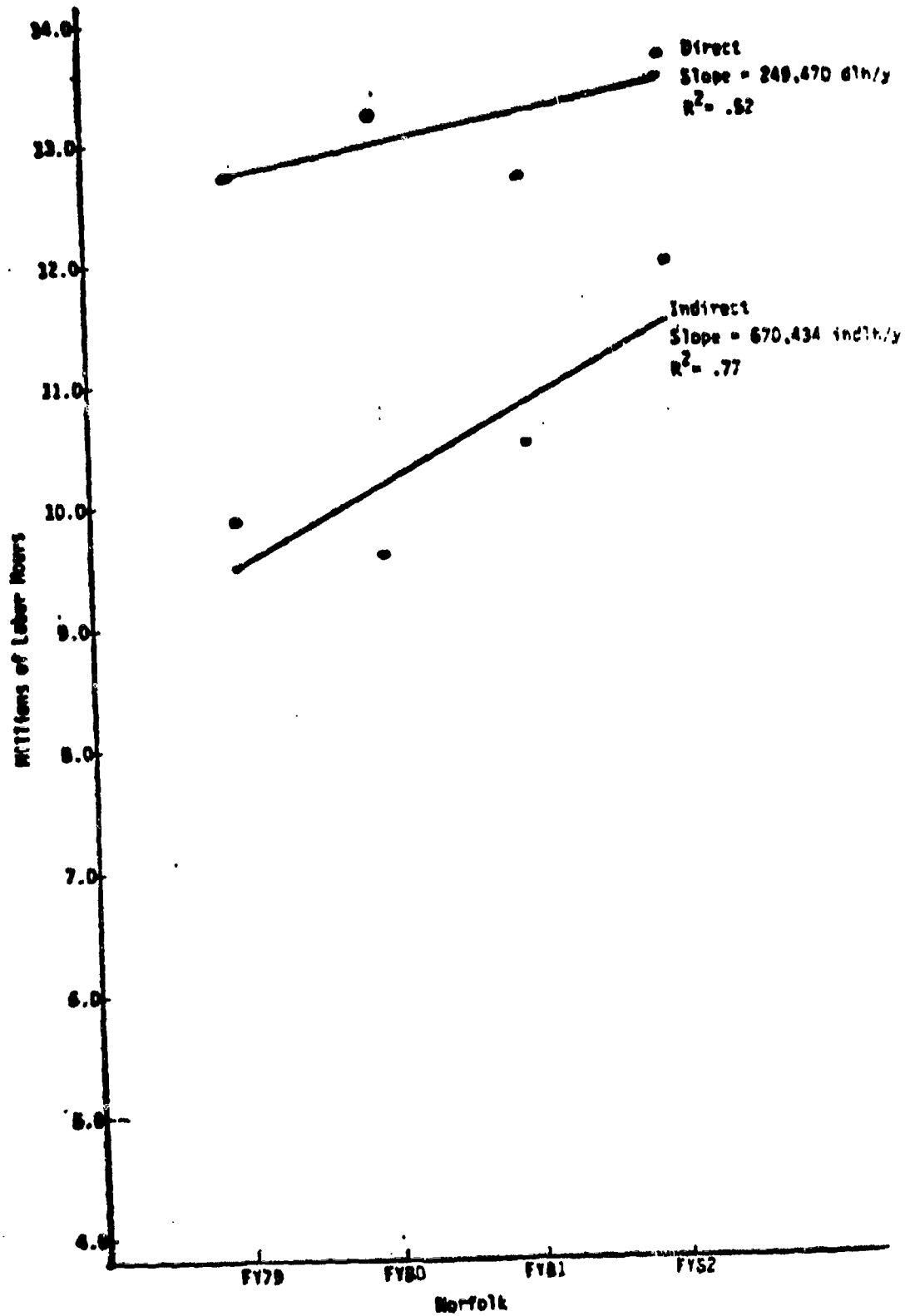


Figure A-3
Growth of Indirect and Direct Labor Hours
Based on Simple Regression Analysis

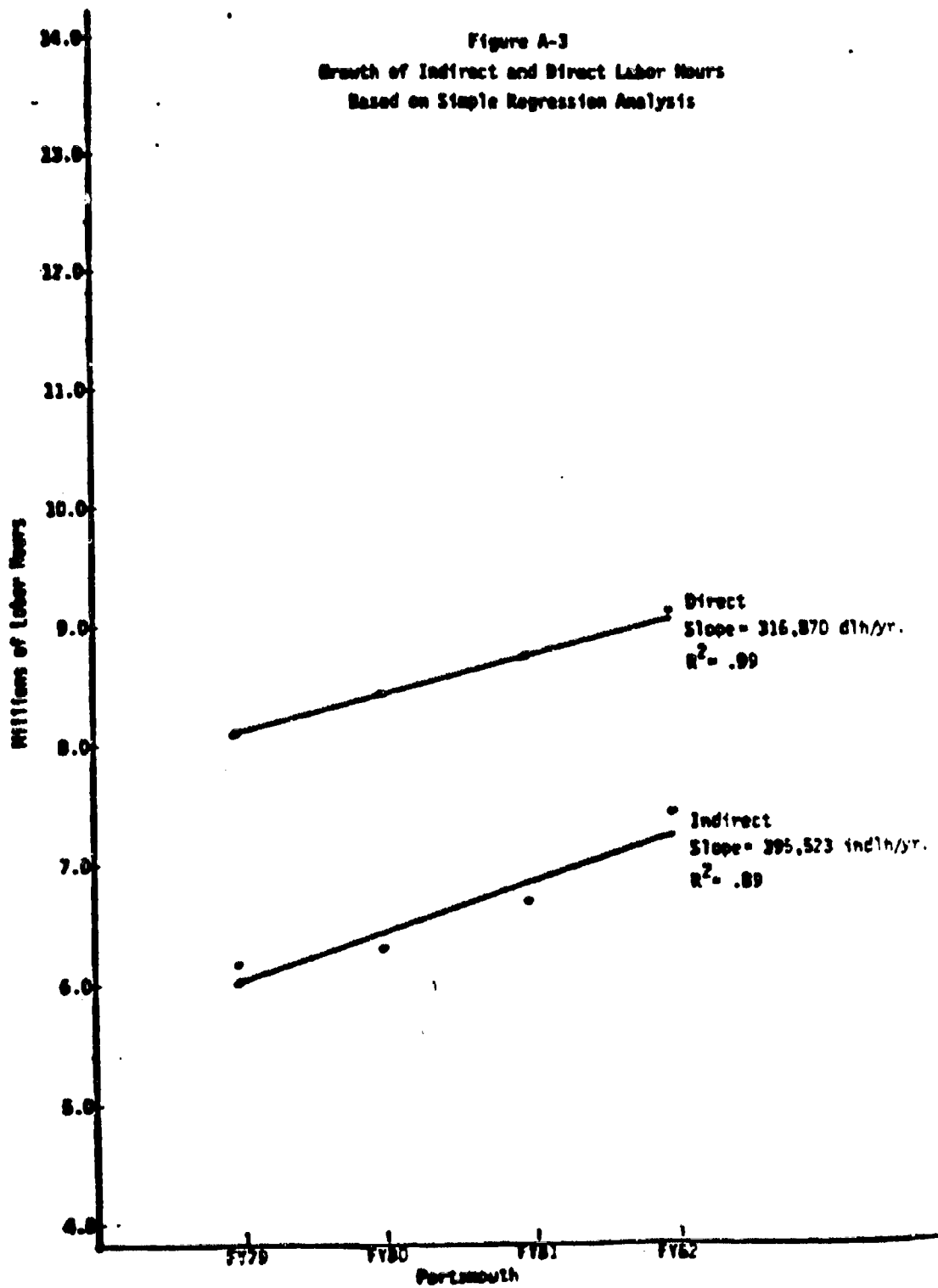


Figure A-4
Growth of Indirect and Direct Labor Hours
Based on Simple Regression Analysis

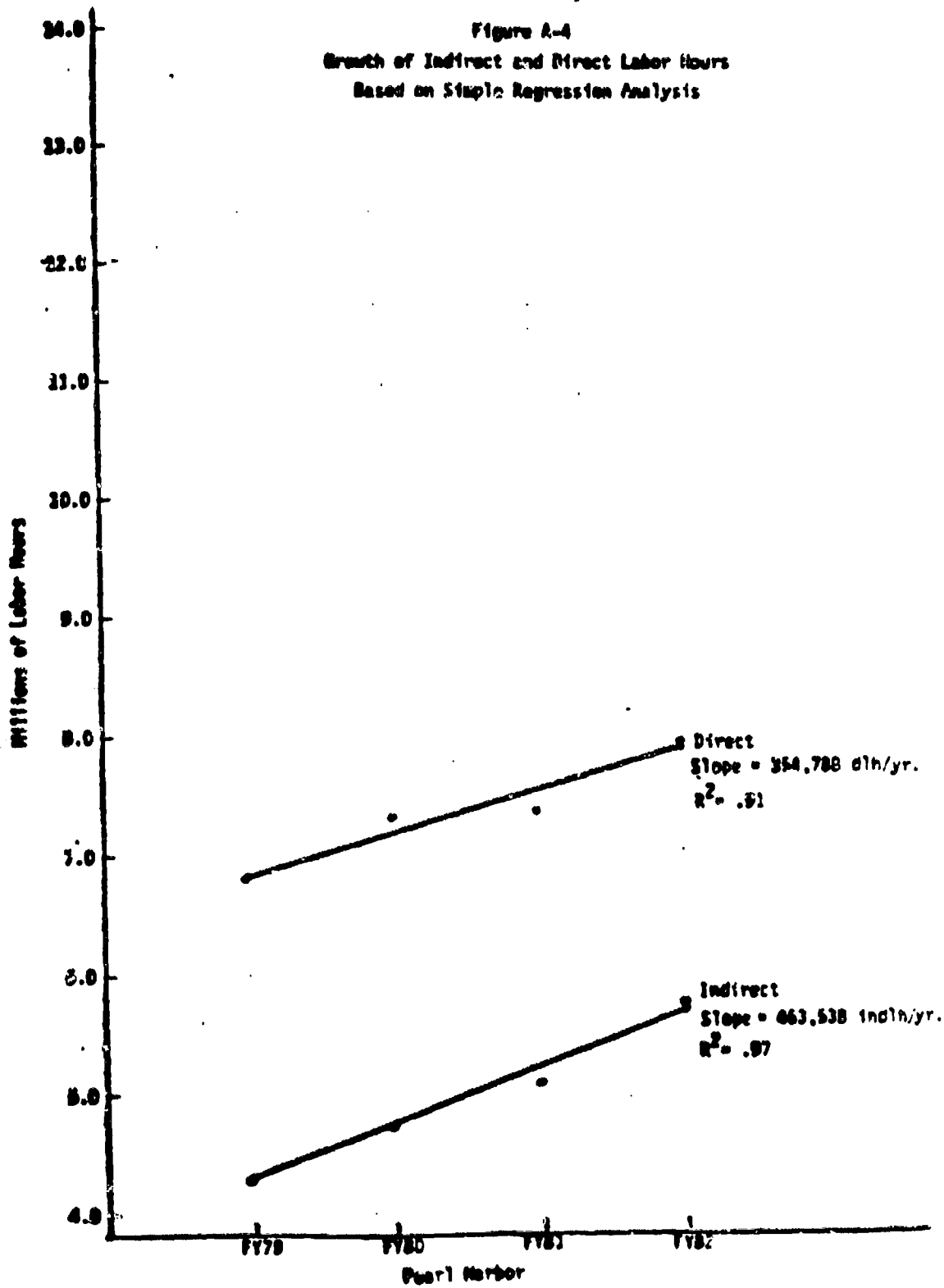


Figure A-5
Growth of Indirect and Direct Labor Hours
Based on Simple Regression Analysis

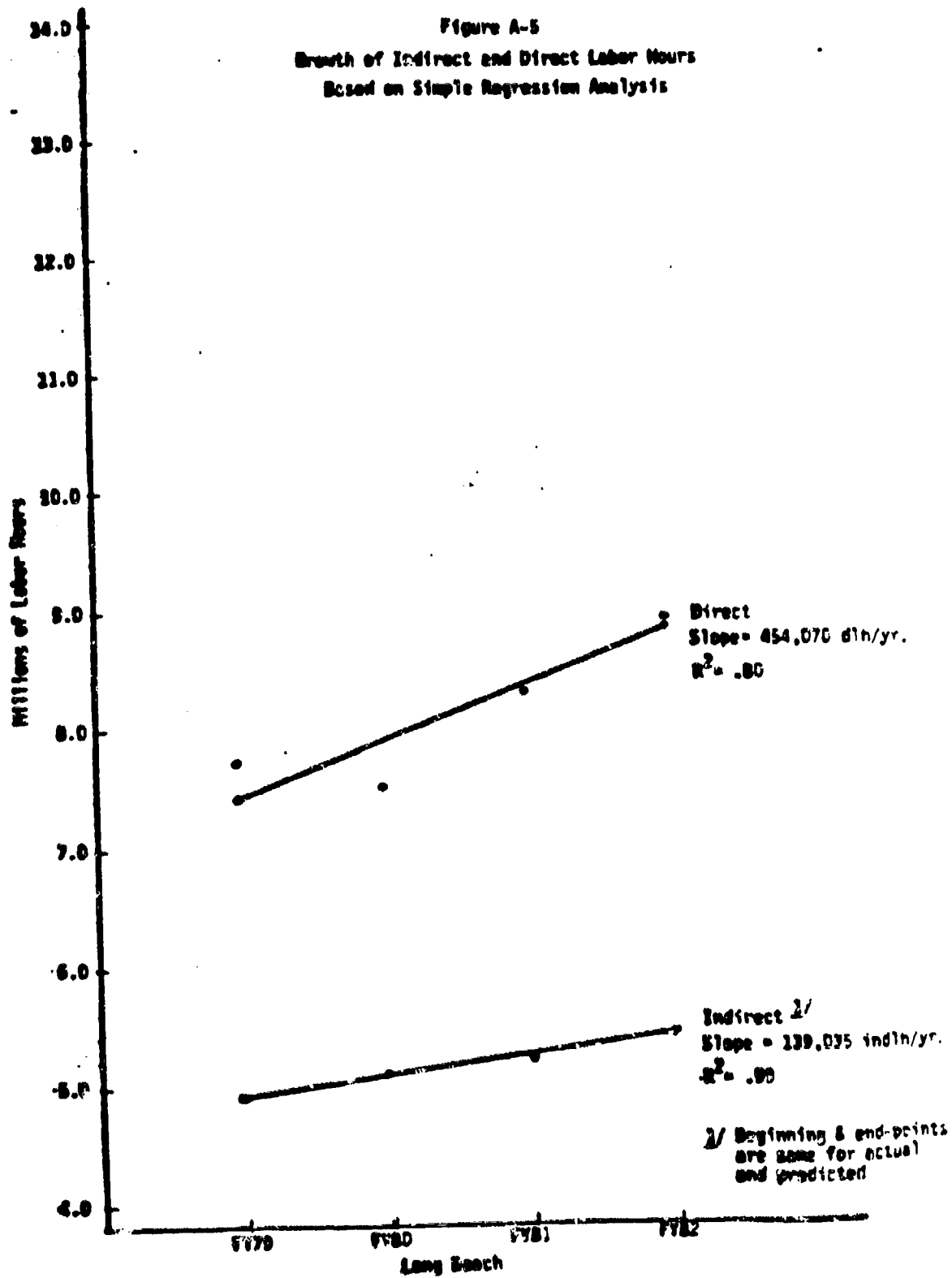


Figure A-6
Growth of Indirect and Direct Labor Hours
Based on Simple Regression Analysis

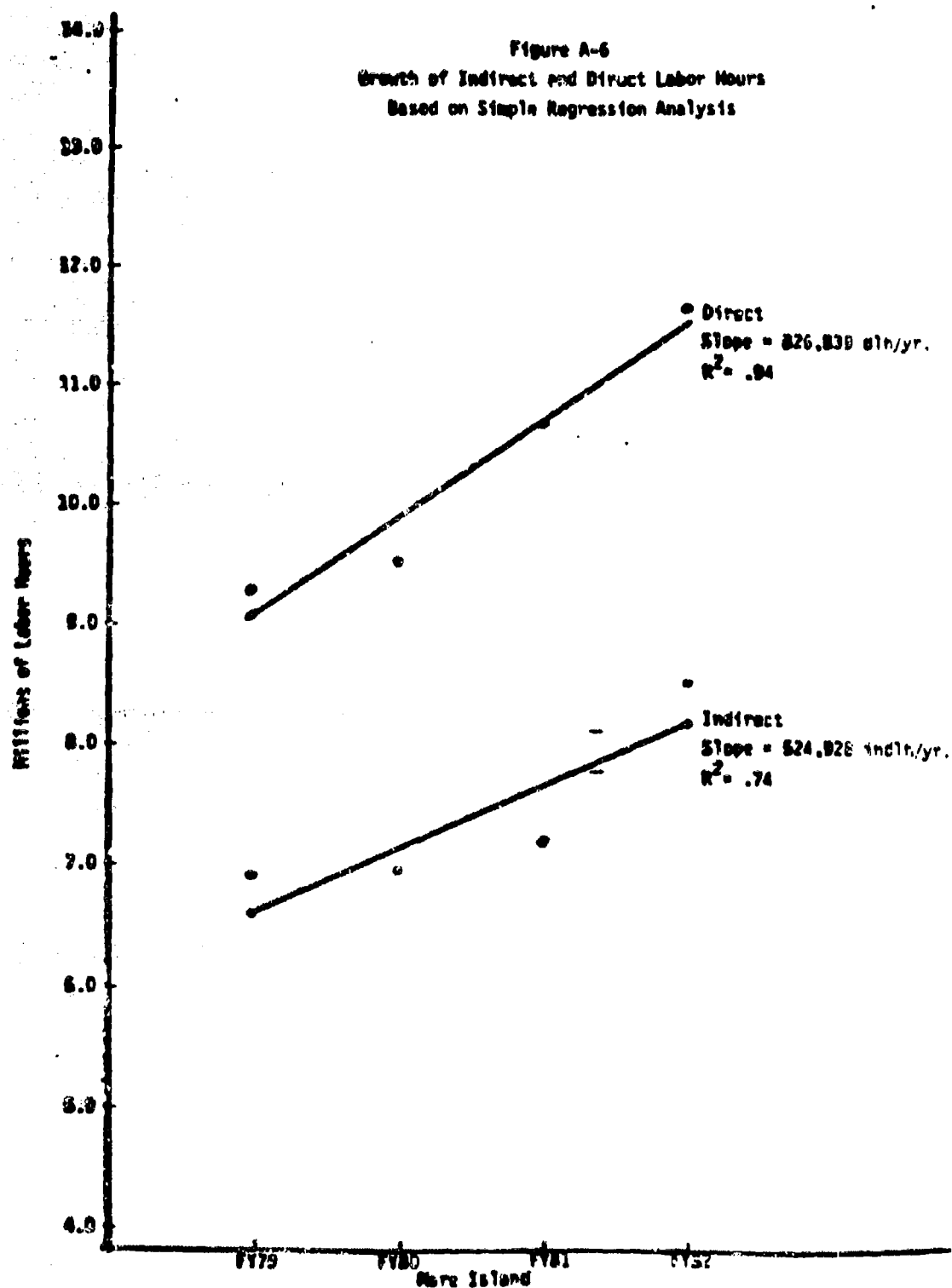


Figure A-7
Growth of Indirect and Direct Labor Hours
Based on Simple Regression Analysis

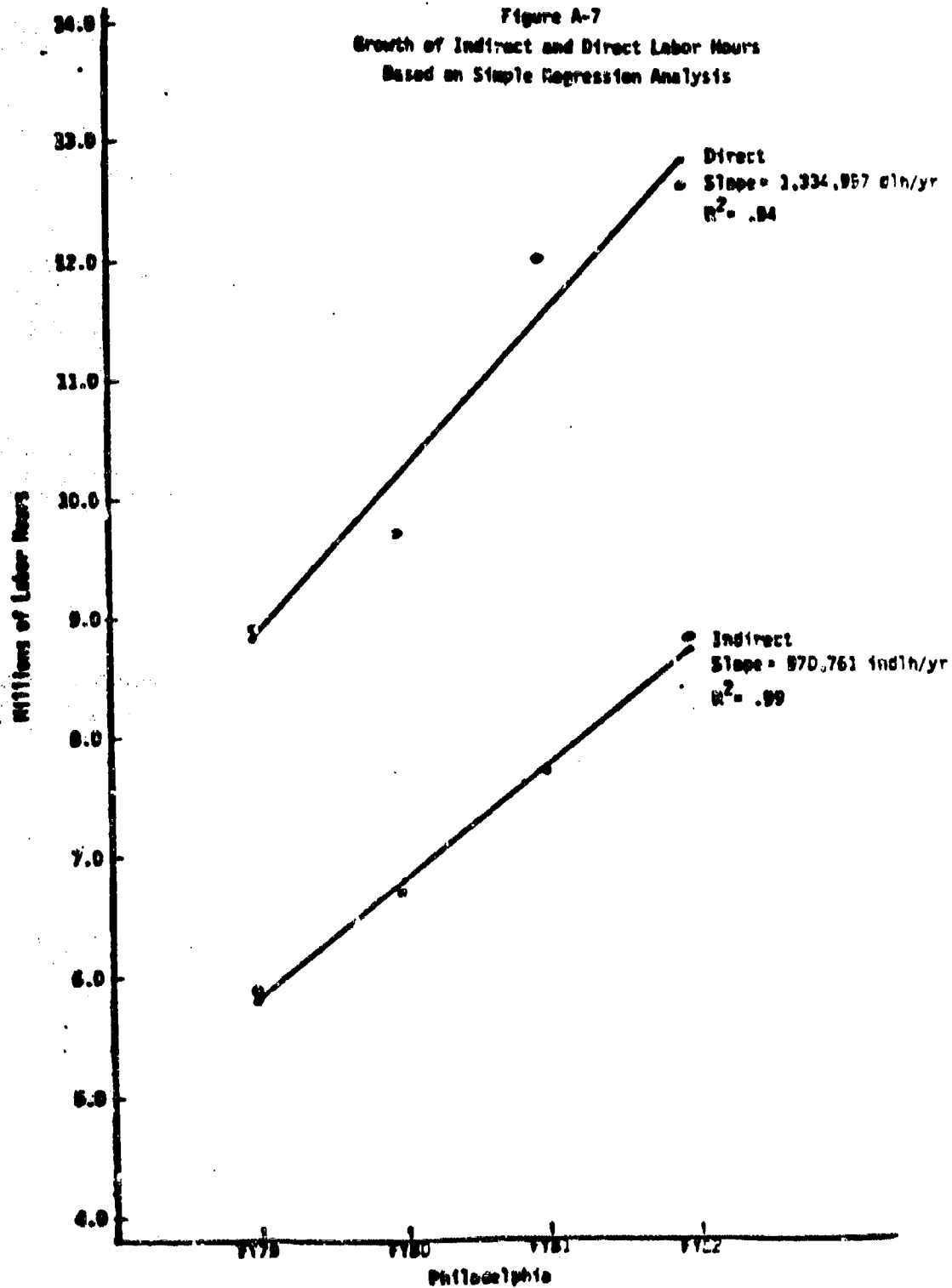


Figure A-8
Growth of Indirect and Direct Labor Hours
Based on Simple Regression Analysis

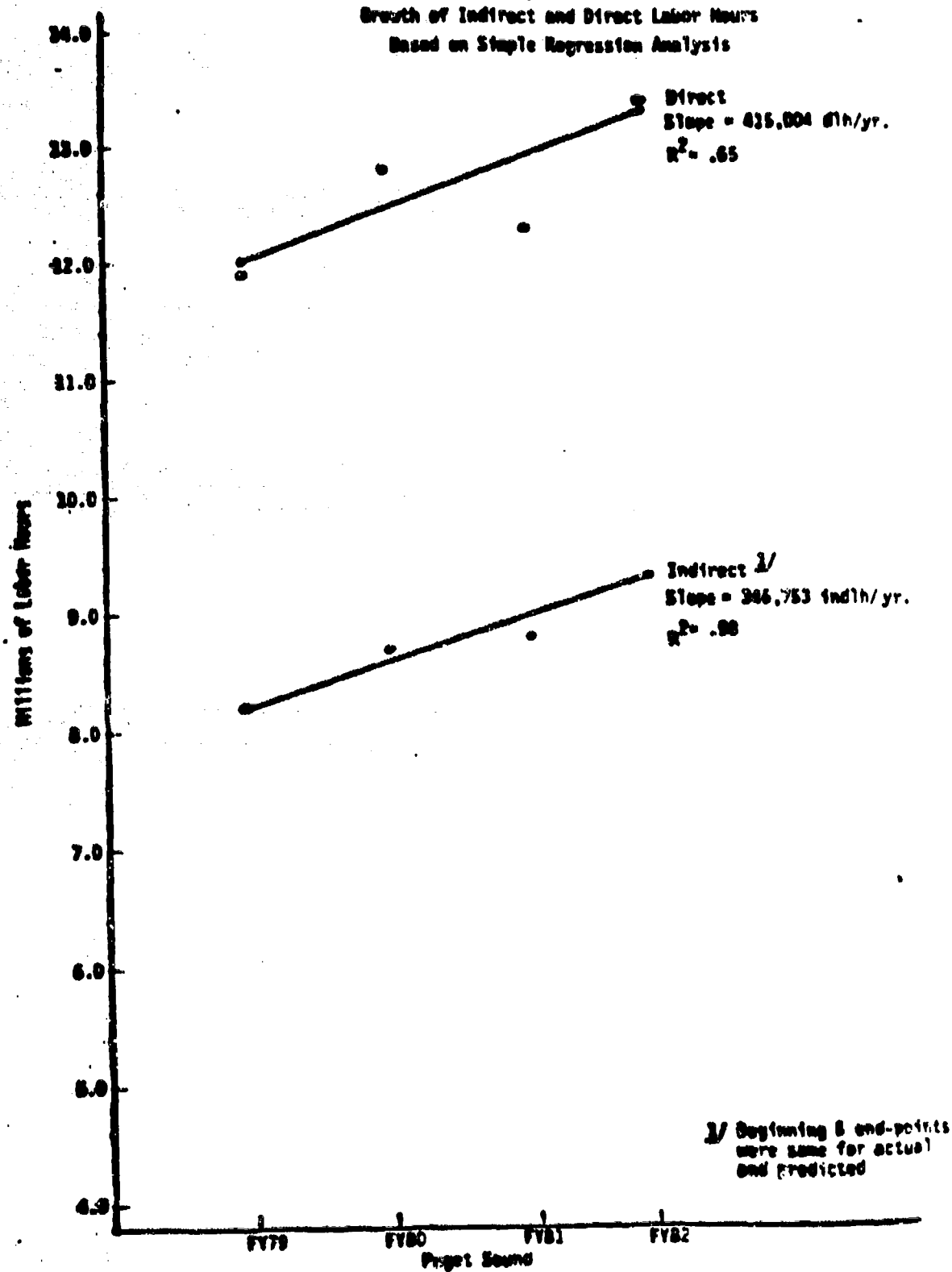


Table A-3
Norfolk
Production Work Center Labor Hours

Work Center	1979	1982	1979	1982	1979	1982	1979	1982	1979	1982
	Direct	Indirect	D/I	Direct	Indirect	D/I	Complex	Non-Complex	Total Direct	Total Indirect
Inside Machine	802264	358874	2.24	889819	430113	2.07	Complex		4080833	1439676
Electrical	1211720	314133	3.86	1062302	354629	3.00	Non-Complex		7388023	2503846
Design	737031	106656	6.91	730326	102627	7.12				
Non-Destructive Test	112066	63994	1.75	113551	83140	1.37				
Radiological Control	62725	76844	.82	146095	215249	.68				
Nuclear Inspection	103160	71032	1.45	283331	148733	1.90				
Laboratory	57011	35084	1.63	81474	34716	2.35				
Nuclear Engineering	127332	124810	1.02	331789	240321	1.38				
SSM Proj Office	56769	15732	3.61	57116	13995	4.08	Non-Complex			
Combat Systems	156130	28947	5.39	168350	34170	4.93				
Electronics	654725	243600	2.69	591897	353518	1.67				
Riggers & Laborers	1001924	347925	2.88	1091981	423972	2.56				
Non-Nuclear Inspection	143922	82334	1.75	171553	70153	2.44				
Shipfitter	905056	266604	3.39	800433	312785	2.56				
Sheetmetal	610199	172815	3.53	492499	190001	2.59				
Welding	844701	367896	2.30	824042	411019	2.00				
Outside Machine	955476	347430	2.75	1195424	459485	2.60				
Boiler	380115	150099	2.53	372782	235827	1.58				
Pipe	1597265	531326	3.01	1849173	635329	2.91				
Woodworking	495328	130695	3.79	446753	147683	3.02				
Paint	454037	106732	4.25	474043	124996	3.79				

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Table A-4
Puget Sound
Production Work Center Labor Hours

Work Center	1979		D/I		1982		D/I		1979 Total Direct	Total Indirect	1982 Total Direct	Total Indirect
	Direct	Indirect			Direct	Indirect						
Inside Machine	1030391	325001	3.17		969275	345949	2.80		4417936	1537771	4812378	2312983
Electrical	823688	207585	3.97		954553	231218	4.13	Non-Complex	6459836	1923968	7612278	2079603
Electronics	456663	133300	3.43		448003	157885	2.84					
Design	846827	173032	4.89		984278	191526	5.14					
Non-Destructive Test	123320	46381	2.66		122116	46187	2.64					
Radiological Control	221767	208750	1.06		249513	271858	.92					
Nuclear Inspection	203093	92940	2.19		176142	91383	1.93					
Laboratory	85155	21885	3.89		72912	34424	2.12					
Nuclear Engineering	508854	294697	1.73		707432	492182	1.44					
Combat Systems	118178	34200	3.46		129154	35371	3.65	Non-Complex				
Non-Nuclear Inspection	10411	8551	1.22		45605	12582	3.62					
Shipfitters	651457	176226	3.70		770778	229534	3.36					
Sheetmetal	492392	108128	4.55		612116	133250	4.59					
Forge	19093	7565	2.52		23848	10313	2.31					
Welding	762721	249267	3.05		982448	279473	3.52					
Outside Machine	1251901	333621	3.87		1355637	368054	3.68					
Boiler	211365	55331	3.82		232922	57932	4.02					
Pipe	1436291	462837	3.10		1831210	424044	4.32					
Woodworking	248210	88954	2.79		257001	89096	2.88					
Paint	532556	134391	3.96		601909	144853	4.16					
Riggers & Laborers	785652	291586	2.69		851949	277388	3.07					
Pattern	17787	7511	2.36		13474	7019	1.92					
					33381	46065	.72					

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Table A-5
Philadelphia
Production Work Center Labor Hours

Work Center	1979 Direct	1979 Indirect	D/I	1982 Direct	1982 Indirect	D/I	1979 Total Direct	1979 Total Indirect	1982 Total Direct	1982 Total Indirect
Inside Machine	764916	189821	4.03	748076	233220	3.21				
Electrical	771939	159118	4.85	749432	195806	3.83	Complex	2964018	715139	3277650
Electronics	511295	159636	3.20	466492	182288	2.56	Non-Complex	4972505	1106155	8142277
Manufacturing Branch	20844	7572	2.75	171414	85379	2.01				
Engineering Branch	---	365	N.A.	10043	30841	.48				
Design	659651	111859	5.90	782871	110068	7.11				
Non-Destructive Test	55833	19206	2.91	73469	22787	3.22				
Laboratory	34837	19743	1.75	41361	17870	2.31				
Combat Systems	199978	47769	4.19	234492	73995	3.16				
Shipfitter	471191	95705	4.87	620124	188815	3.28				
Sheet Metal	414259	79870	5.19	631988	139649	4.52				
Welding	468205	121615	3.84	943316	245976	3.83				
Outside Machine	776704	163774	4.60	1231936	342895	3.59				
Boiler	219467	75265	2.92	529267	128537	4.11				
Pipe	1255517	231531	5.43	2039503	421654	4.83				
Woodworking	266650	77037	3.45	373832	119859	3.19				
Paint	417471	96019	4.35	714435	144768	4.93				
Riggers & Laborers	576965	142165	4.06	890151	239090	3.72				
Non-Nuclear Inspection	103076	16374	6.22	167723	29187	5.75				
Temporary Services	137433	41102	3.34	308893	69812	4.42				



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Table A-6
 Mare Island
 Production Work Center Labor Hours

Work Center	1979		D/I	1982		D/I	1979		Total Direct	Total Indirect	1982	
	Direct	Indirect		Direct	Indirect		Direct	Indirect			Total Direct	Total Indirect
Inside Machine	575023	182153	3.16	707363	247450	2.86			Complex	4062482	1488394	1797725
Weapons	402078	127378	3.16	0	0	0			Non-Complex	4584013	1502663	2016853
Electrical	761654	243890	3.12	1084385	345575	3.14						
Electronics	396845	145766	2.72	773808	272621	2.84						
Design	1094178	237784	4.72	1257278	230521	5.45			FY79-FY82	Percentage Increase		
Non-Destructive Test	74880	28242	2.55	87423	38436	2.27			Complex	Direct	+14.1%	
Radiological Control	115246	158633	.73	132083	210224	.63			Complex	Indirect	+20.7%	
Nuclear Inspection	214995	100546	2.14	163508	114214	1.43			Non-Complex	Direct	+35.6%	
Laboratory	74131	35392	2.09	76025	49166	1.55			Non-Complex	Indirect	+34.2%	
Nuclear Engineering	260534	182483	1.43	244347	236702	1.03						
Combat Systems	93118	50827	1.83	112065	52816	2.12						
Shipfitter	497696	137045	3.63	694764	223193	3.11						
Sheetmetal	306611	78965	3.88	483160	132323	3.65						
Forge	24939	11413	2.18	24339	16494	1.48						
Welding	434348	159795	2.72	657334	193141	3.40						
Outside Machine	876512	380456	2.30	953974	417383	2.29						
Boiler	77091	23955	3.22	101084	31202	3.24						
Pipe	1046076	268946	3.89	1365251	382401	3.57						
Woodworking	280606	82454	3.40	447704	115798	3.87						
Paint	299934	94544	3.17	488269	144998	3.37						
Riggers & Laborers	582033	227851	2.55	778034	284043	2.74						
Non-Nuclear Inspection	158172	37239	4.25	179670	49530	3.63						
Calibration Center				43207	26347	1.64						
Temporary Services	208256	75139	2.77	285863	126877	2.25						



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Table A-7
Portsmouth
Production Work Center Labor Hours

Work Center	1979		D/I	Direct	Indirect	1982		D/I	Direct	Indirect	1979		Total Indirect	1982		Total Indirect
	Direct	Indirect														
Inside Machine	586108	234753	2.50			681277	303023	2.25								
Electrical	431149	134942	3.19			611212	214057	2.85			Complex	2616162	1010958	3041081	1421882	
Electronics	339131	94249	3.60			352318	112181	3.14			Non-Complex	4367717	1303436	4691846	1542091	
Design	616321	129547	4.76			626765	137541	4.56								
Radiological Control	138772	108772	1.28			141969	219185	.64								
Nuclear Inspection	132922	86538	1.54			147768	116304	1.27								
Laboratory	64570	25042	2.58													
Nuclear Engineering	206754	160273	1.29			280465	210413	1.33					Complex		Percentage Increase	
Combat Systems	100435	36842	2.73			127243	51558	2.47					Complex		Direct = 185	
Non Destructive Test						43276	41857	1.03					Non-Complex		Indirect = 415	
Material Test						28798	15793	1.82					Non-Complex		Direct = 75	
Shipfitters	470869	145272	3.24			532503	173464	3.07								
Sheetmetal	305153	64311	4.74			325441	73700	4.41								
Welding	327464	124347	2.63			405210	164565	2.46								
Outside Machine	678281	240723	2.82			805486	328393	2.45								
Pipe	1174179	334826	3.51			1041933	354668	2.94								
Woodworking	242183	82504	2.94			411542	117438	3.50								
Paint	743806	156964	4.74			750846	184753	4.06								
Riggers & Laborers	265405	77774	3.41			275811	93177	2.96								
Non-Nuclear Inspection	180377	75695	2.09			143074	51933	2.75								

Complex

Non-Complex



Table A-8
Long Beach
Production Work Center Labor Hours

Work Center	1979		1982		1979 Total Direct	1979 Total Indirect	1982 Total Direct	1982 Total Indirect	1982 Total
	Direct	Indirect	Direct	Indirect					
Complexity									
Inside Machine	626179	152609	641847	172784	Complex	2564563	721531	3000134	792279
Weapons	214490	77042	259561	78531	Non-Complex	4120300	1351502	5135205	1153638
Electrical	645378	158442	871184	175111					
Electronics	235950	143036	326880	150645					
Design	646274	123378	708608	152925					
Laboratory	26962	20507	15454	13859					
Combat Systems	165335	66517	176600	48422					
					FY79-FY82 Percentage Increase				
Shipfitters	423781	109200	537516	121966	Complex	Direct = 16.9%			
Sheetmetal	401289	69831	411132	76580	Complex	Indirect = 9.8%			
Welding	467799	116490	568697	135589	Non-Complex	Direct = 18.6%			
Outside Machine	493127	117712	497651	117611	Non-Complex	Indirect = 14.6%			
Roller	326971	92673	297642	82827					
Pipe	901777	193617	855344	139485					
Insulator	-	-	240721	44392					
Woodworking	294979	75862	308745	75346					
Paint	331544	81398	417769	83756					
Riggers & Laborers	557929	171610	716581	165650					
Non-Nuclear Inspection	130104	38952	150952	43698					
Temporary Services	126239	68157	132535	66740					

Complex

Non-Complex



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Table A-9
Charleston
Production Work Center Labor Hours

Work Center	Direct	Indirect	D/I	1979	1982	D/I	1979	1982	Total Indirect	1982	Total Indirect
Inside Machine	627478	254234	2.47		550068	248743	2.21				
Electrical	446059	105727	4.22		516214	143320	3.60	Complex	2649855	1044674	2759893
Electronics	332043	118742	2.80		337311	146911	2.30	Non-Complex	4363376	1130727	4544950
Design	563638	100858	5.59		544959	99340	5.49				
Non-Destructive Test	80991	33714	2.40		121746	42327	2.88				
Radiological Control	77897	137857	.57		97613	142107	.69	FY79- FY82 Percentage Increase			
Nuclear Inspection	145300	101663	1.43		162958	103945	1.58	Complex Direct = 3.1%			
Laboratory	71989	18634	3.81		77716	26173	2.97	Complex Indirect = 10.2%			
Nuclear Engineering	160343	145054	1.11		201868	161700	1.25	Non-Complex Direct = 4.1%			
Combat Systems	144117	27941	5.16		149440	37648	3.97	Non-Complex Indirect = 12.6%			
Shipfitters	398500	99420	4.01		468932	126109	3.72				
Sheetmetal	286943	57788	4.97		279401	64604	4.32				
Welding	429293	121831	3.52		523112	158111	3.31				
Outside Machine	828087	222525	3.72		844611	233608	3.61				
Boiler	262339	48356	5.43		197101	51455	3.83				
Pipe	1048870	310570	3.38		1031049	322910	3.19				
Woodworking	219106	49978	4.38		246932	63553	3.88				
Paint	198233	46099	4.30		273008	66747	4.09				
Riggers & Laborers	604058	149185	4.05		592155	159056	3.72				
Non Nuclear Inspection	97947	24975	3.52		88649	28066	3.15				
Temporary Services	263551	1738276	3.42		287324	151704	1.89				

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Table A-10
Pearl Harbor
Production Work Center Labor Hours

	Direct D	1979 Indirect I	D/I	Direct D	1982 Indirect I	D/I		1979 Total Direct	1979 Total Indirect	1982 Total Direct	1982 Total Indirect
Work Center											
Inside Machine	700597	146059	4.80	730538	197439	3.70					
Electrical	463062	123085	3.76	540067	146163	3.69	Complex	2393436		809440	1162795
Electronics	401669	126496	3.18	370405	151584	2.44	Non-Complex	3806744		826992	1250898
Design	421001	57921	7.27	415622	75830	5.48		FY79-FY82 Percentage Increase			
Non-Destructive Test	56637	26707	2.12	57315	31611	1.81	Complex	Direct		=12.4%	
Radiological Control	48026	116322	.41	139269	236414	.59	Complex	Indirect		=43.6%	
Nuclear Inspection	51747	50469	1.03	100955	68630	1.47	Non-Complex	Direct		=19.8%	
Laboratory	44829	24317	1.84	53168	25867	2.05	Non-Complex	Indirect		=51.2%	
Nuclear Engineering	108662	110065	.99	197969	191448	1.03					
Combat Systems	97206	27999	3.47	86658	37789	2.29					
Shipfitter	345117	68394	5.05	448026	106220	4.22					
Sheetmetal	198284	37034	5.35	242421	54353	4.46					
Forge	39527	8379	4.72	44250	14998	2.95					
Welding	357062	75234	4.75	492304	141936	3.47					
Outside Machine	727262	188781	3.85	934387	269723	3.46					
Boiler	458053	62775	7.30	405720	85549	4.74					
Pipe	729274	159063	4.58	879849	255058	3.45					
Woodworking	214030	48928	4.37	219593	65760	3.34					
Paint	256465	51311	5.00	327529	80639	4.06					
Riggers & Laborers	417319	98168	4.25	467090	123397	3.61					
Non-Nuclear Inspection	64351	28925	2.22	99597	47265	2.11					
Temporary Services	187334	70272	2.67	236094	120062	1.97					

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Table A-11

**NUMBER OF PLANNED MANDAYS FOR SHIP REPAIR
AND NON-NUCLEAR ALTERATIONS BY SHIPYARD FOR FY79 AND FY82**

Shipyards	FY79	FY80	FY81	FY82
Portsmouth	562,422	745,849	669,901	700,549
Philadelphia	604,002	363,427	447,720	575,369
Norfolk	1,194,944	1,428,774	1,147,045	1,346,585
Charleston	422,068	771,061	633,317	832,442
Long Beach	746,176	847,919	612,266	706,722
Marine Island	1,228,879	1,251,609	934,579	1,023,254
Puget Sound	1,276,944	993,260	1,584,551	966,186
Pearl Harbor	889,804	533,320	845,467	575,691
	<u>6,925,239</u>	<u>6,935,219</u>	<u>6,874,846</u>	<u>6,726,798</u>

NAVSEA 0733 Stabilized Manday Rate Submissions, Serial 92/073 of March 7, 1978; Serial 59/0733 of February 16, 1979; Serial 412/073 of June 3, 1980; and Serial 220/073 of April 20, 1981.

Appendix B

BACK-UP DISCUSSION FOR COST BEHAVIOR

The tables, figures, and narratives in this appendix support and supplement the summary discussion in the main text (Section 3) on shipyard cost behavior and growth. Subjects discussed include:

- o Inflation factors used to convert actual dollars into constant FY84 dollars;
- o Total costs broken down by total direct costs and total indirect costs;
- o Direct costs by labor, material, contractual and other;
- o Indirect costs by labor, material, contractual and other;
- o Indirect costs by type of overhead;
- o Indirect general and administrative expense centers; and
- o Indirect significant program costs.

Each subject will be discussed in turn.

Inflation Factors and Inflation Sensitivity

The escalation indices used in this analysis are mid-FY84 factors for civilian pay, O&MN purchases and fuel⁴ and reflect the inflation experienced by actual expenditures. Separate indices were applied to appropriate cost categories, rather than applying one weighted index to all costs, because no single published index accurately reflected the composition of shipyard costs.

⁴ Escalation Indices and Outlay Profile Factors, Chief of Naval Operations, Systems Analysis Division, Resource Analysis Branch, January 1983.

Application of escalation indices to the cost elements reported in the F10 statements is explained below. The civilian pay index used for labor costs, supervisory program costs, and non-supervisory program costs are .782, .835, .908, and .957. The O&MN purchases index (.685, .751, .841 and .904) was used to adjust non-labor direct costs and indirect material costs to constant dollars. For indirect contract and other costs and purchased utilities, we computed a composite of the O&MN purchases and fuel indices. We assumed that fuel costs were the "other", (non-labor and non-material), portion of public works utilities costs, which are included in overhead. A four year average of these costs were computed, a proportion of total indirect contract and other costs; the resulting ratios were applied to the fuel portion of the composite index. The computed contract and other factors are: .604, .789, .904, and .937.

For indirect costs, the sum of the constant dollar components for labor, material, contract and other was divided into total actual costs to get a composite escalation index. These overall factors: .727, .816, .902 and .947 were used to adjust production, manufacturing, and G&A overhead and the training, recurring maintenance, and MNRM indirect program costs.

Some of the study results are sensitive to the selection of inflation factors. We tested this by using the O&MN weighted escalation index, (.658, .794, .886, .933) to convert actual expenditures into constant dollar costs. With the O&MN weighted index, total costs increased 9% versus 22%, indirect costs grew faster than direct costs, and total costs per direct labor hour declined. However, material and contract costs still increased at a faster rate than labor costs; production and manufacturing overhead costs still grew faster than G&A costs; and individual shipyard direct and indirect growth rates remained relatively the same. The main reason for the different results is the

variation in cost composition between the shipyards and the factors in the O&MN weighted index. According to the Office of the Secretary of Defense, Program Analysis and Evaluation, the approximate O&MN weighted index is 35% pay, 15% fuel and 50% purchases; while average shipyard composition between FY79 and FY82 is 66% pay, 4% fuel, and 30% purchases. The difference in labor (civilian pay) composition and the fact that civilian pay inflation was lower than purchases and fuel resulted in higher real growth rates when separate escalation indices were used rather than the weighted O&MN index.

Total Costs

Although total, actual costs increased 55% for all eight shipyards between FY79 and FY82, individual shipyard cost growth varied from 43% at Puget Sound to 87% at Philadelphia, Table B-1 shows the total actual costs, the constant dollar costs by shipyard, and the percent growth in costs between FY79 and FY82. Constant dollar costs decreased for one year at Long Beach in FY80 and Charleston in FY81. In total and at 6 shipyards the largest yearly growth occurred between FY81 and FY82.

Actual and constant dollar direct costs for each shipyard are displayed in Table B-2. Actual direct cost growth from FY79 to FY82 was 54% for all shipyards, but varied from 42% at Pearl Harbor to 88% at Philadelphia. The two non-nuclear shipyards, Philadelphia and Long Beach, had the largest dollar and percentage growth. The Philadelphia increase alone accounted for 21% of all actual direct cost growth and 29% of all constant dollar direct cost growth. Yearly constant dollar direct cost growth for the Naval shipyards was 5%, 7%, and 10% for FYs 80, 81, and 82.

Table B-3 lists indirect costs for each shipyard in actual and constant dollars. Individual shipyard cost growth, in actual dollars, ranged from 37% at Long Beach to 85% at Philadelphia; it was 57% for all shipyards. Philadelphia's operation had a smaller, but still significant impact on indirect costs, accounting for about 19% of the total actual indirect cost increase and 24% of the total constant dollar increase. Year-to-year constant dollar indirect cost growth for all shipyards was 2% between FY79 and FY80, 3% between FY80 and FY81, and 14% between FY81 and FY82.

Reimbursements were a constant 4.5% of indirect costs in each of the four years studied; so reimbursements do not account for the growth in indirect costs. Constant dollar indirect costs with reimbursable expenses deducted are shown by the total figures for each shipyard in Table B-8. A comparison of the total percentage increases in Table B-8, with the percentage increases in Table B-3 (which include reimbursable expenses) shows that the increases are similar. The largest difference occurred at Philadelphia where costs after reimbursements increased 5% faster than costs including reimbursements.

Total, direct, and indirect costs in constant dollars per DLH are displayed by shipyard in Table B-4. The constant dollar total cost DLH for all shipyards increased 4% over the four years studied, from \$40.33 in FY79 to \$42.05 in FY82. Surprisingly, the non-nuclear yards had the highest or relatively high total rates every year, but their growth rates were low. Portsmouth always had the lowest total cost per DLH, but it showed the largest rate of increase. For direct costs per DLH, Long Beach and Philadelphia again had the highest costs per DLH and Portsmouth had the lowest. In FY82 direct costs per DLH ranged from \$29.98 at Long Beach to \$21.38 at Portsmouth. Direct costs per DLH decreased at

Table B-1
TOTAL COSTS*

	(\$000)				
	FY79	FY80	FY81	FY82	% Increase FY79-FY82
<u>Actual \$</u>					
Norfolk	364,027	405,497	467,311	544,845	50%
Puget Sound	347,137	392,786	435,322	497,804	43%
Philadelphia	283,392	342,717	435,855	529,096	87%
Mare Island	299,093	328,029	387,036	453,798	52%
Portsmouth	210,682	240,570	279,688	329,488	56%
Long Beach	248,210	261,733	307,611	381,642	54%
Charleston	233,424	275,830	301,672	340,666	46%
Pearl Harbor	211,753	247,442	273,090	328,294	55%
Total	2,197,718	2,494,604	2,887,585	3,405,633	55%
<u>Constant FY84\$</u>					
Norfolk	498,052	503,159	526,081	580,076	16%
Puget Sound	463,944	483,719	489,131	528,690	14%
Philadelphia	390,854	427,182	491,377	564,651	45%
Mare Island	401,035	402,228	433,006	480,521	20%
Portsmouth	282,785	295,921	311,967	349,843	24%
Long Beach	339,551	324,869	346,661	407,681	20%
Charleston	314,752	340,166	338,308	361,714	15%
Pearl Harbor	284,953	304,544	305,726	347,933	22%
Total	2,975,926	3,081,788	3,242,257	3,621,109	22%

From Financial and Operating Statements, Exhibit B,
Statement of Revenue and Costs.

* Total Costs Incurred, before adjustments for reimbursements, manufacturing for inventory, fixed asset purchase, and work-in-process.

Table B-2
DIRECT COSTS

	(\$000)				% Increase FY79-FY82
	FY79	FY80	FY81	FY82	
<u>Actual \$</u>					
Norfolk	212,680	241,770	264,829	306,002	44%
Puget Sound	217,497	242,227	268,687	310,583	43%
Philadelphia	169,368	207,489	265,755	318,712	88%
Mare Island	170,971	185,559	231,136	261,287	53%
Portsmouth	119,132	131,226	156,348	182,458	53%
Long Beach	152,031	158,128	193,321	249,763	64%
Charleston	130,476	153,523	169,991	186,955	43%
Pearl Harbor	129,271	146,012	163,480	184,177	42%
Total	1,301,426	1,465,934	1,713,547	1,999,937	54%
<u>Constant FY84\$</u>					
Norfolk	287,293	302,710	301,458	327,928	14%
Puget Sound	290,879	299,994	304,076	331,160	14%
Philadelphia	228,693	260,690	302,693	342,175	50%
Mare Island	226,312	228,322	260,217	277,506	23%
Portsmouth	158,436	161,903	175,282	194,602	23%
Long Beach	205,160	197,649	219,741	268,281	31%
Charleston	173,515	190,126	192,362	199,322	15%
Pearl Harbor	172,051	180,407	184,527	195,818	14%
Total	1,742,339	1,821,801	1,940,356	2,136,792	23%

From Financial and Operating Statements, Exhibit B, Statement of Revenue and Costs.

Table B-3
INDIRECT COSTS

			(\$000)		
	FY79	FY80	FY81	FY82	% Increase FY79-FY82
<u>Actual \$</u>					
Norfolk	151,347	163,727	202,482	238,843	58%
Puget Sound	129,640	150,559	166,635	187,221	44%
Philadelphia	114,024	135,228	170,100	210,384	85%
Mare Island	128,122	142,470	155,900	192,511	50%
Portsmouth	91,550	109,344	123,340	147,030	61%
Long Beach	96,179	103,605	114,290	131,879	37%
Charleston	102,948	122,307	131,681	153,711	49%
Pearl Harbor	82,482	101,430	109,610	144,117	75%
Total	896,292	1,028,670	1,174,038	1,405,696	57%
<u>Constant FY84\$</u>					
Norfolk	210,759	200,449	224,623	252,148	20%
Puget Sound	173,065	183,725	185,055	197,530	14%
Philadelphia	162,161	166,492	188,684	222,476	37%
Mare Island	174,723	173,906	172,789	203,015	16%
Portsmouth	124,349	134,018	136,685	155,241	25%
Long Beach	134,391	127,220	126,920	139,400	4%
Charleston	141,237	150,040	145,946	162,392	15%
Pearl Harbor	112,902	124,137	121,199	152,115	35%
Total	1,233,587	1,259,987	1,301,901	1,484,317	20%

From Financial and Operating Statements, Exhibit B, Statement of Revenue and Costs.

* Reimbursable Costs have not been deducted from these costs.

Table B-4

**TOTAL, DIRECT AND INDIRECT COSTS PER DIRECT LABOR HOUR
(Constant FY84\$)**

	FY79	FY80	(FY81)	(FY82)
Total Costs per Direct Labor Hour				
Norfolk	\$39.17	\$38.10	\$41.15	\$42.38
Puget Sound	38.94	37.63	39.56	39.28
Philadelphia	43.88	44.10	40.97	44.86
Mare Island	42.87	41.95	40.55	40.90
Portsmouth	34.73	35.13	35.81	38.43
Long Beach	44.11	43.34	41.87	45.56
Charleston	38.22	39.46	40.99	42.10
Pearl Harbor	41.79	41.86	41.75	43.56
Total	40.33	39.95	40.33	42.05
Direct Costs per Direct Labor Hour				
Norfolk	\$22.59	\$22.92	\$23.58	\$23.96
Puget Sound	24.41	23.34	24.59	24.60
Philadelphia	25.67	26.91	25.24	27.18
Mare Island	24.19	23.81	24.37	23.62
Portsmouth	19.46	19.22	20.12	21.38
Long Beach	26.65	26.37	26.54	29.98
Charleston	21.07	22.05	23.31	23.20
Pearl Harbor	25.23	24.80	25.20	24.52
Total	23.61	23.62	24.14	24.81
Indirect Costs per Direct Labor Hour				
Norfolk	\$16.58	\$15.18	\$17.57	\$18.42
Puget Sound	14.53	14.29	14.97	14.68
Philadelphia	18.21	17.19	15.73	17.68
Mare Island	18.68	18.14	16.18	17.28
Portsmouth	15.27	15.91	15.69	17.05
Long Beach	17.46	16.97	15.33	15.58
Charleston	17.15	17.41	17.68	18.90
Pearl Harbor	16.56	17.06	16.55	19.04
Total	16.72	16.33	16.19	17.24

From Financial and Operating Statements: Exhibit B Costs, in Constant Dollars, divided by Exhibit H-1 Direct Labor Hours.

two shipyards over the four years, Mare Island and Pearl Harbor. Indirect costs per DLH declined at three shipyards, Mare Island, Long Beach and Philadelphia. Because both Mare Island and Philadelphia had large increases in the number of direct labor hours, an indirect, unit cost decline would be expected. Pearl Harbor had the largest rate of growth in indirect costs per DLH.

= FY79-FY82 percentage cost increases for total, direct, and indirect costs in actual, constant, and constant dollars per DLH are displayed in Table B-5. Long Beach, Philadelphia and Pearl Harbor had the widest differences in direct and indirect cost growth rates. An important point to note is that in actual and constant dollars, the four year percentage growth in indirect costs was greater than or equal to the percentage growth in direct costs at 5 shipyards, Norfolk, Puget Sound, Portsmouth, Charleston, and Pearl Harbor. At Long Beach direct costs grew significantly and indirect costs changed very little. Mare Island and Philadelphia also had faster growth in direct costs than in indirect costs.

Direct Cost by Labor, Material, Contractual, and Other

Table B-6 lists constant dollar direct costs by labor, material, contractual and other for each shipyard. Labor costs were consistently the largest direct cost area, but fell as a percent of constant dollar direct costs, from 64% in FY79 to 60% in FY82. While total direct labor hours increased 17%, constant dollar direct labor costs only grew 16% so direct labor cost per hour declined. As stated in Section 3, material and contractual costs each increased over 30%.

Table B-5

**TOTAL, DIRECT AND INDIRECT PERCENTAGE COST INCREASES
FY79 to FY82**

	% Increase Total Cost	% Increase Direct Cost	% Increase Indirect Cost
<u>Actual \$</u>			
Norfolk	50%	44%	58%
Puget Sound	43	43	44
Philadelphia	87	88	85
Mare Island	52	53	50
Portsmouth	56	53	61
Long Beach	54	64	37
Charleston	46	43	49
Pearl Harbor	55	42	75
Total	55	54	57
<u>Constant FY84\$</u>			
Norfolk	16%	14%	20%
Puget Sound	14	14	14
Philadelphia	45	50	37
Mare Island	20	23	16
Portsmouth	24	23	25
Long Beach	20	31	4
Charleston	15	15	15
Pearl Harbor	22	14	35
Total	22	23	20
<u>Constant FY84\$ per Direct Labor Hours</u>			
Norfolk	8%	6%	11%
Puget Sound	1	1	1
Philadelphia	2	6	- 3
Mare Island	- 5	- 2	- 8
Portsmouth	11	10	12
Long Beach	3	13	-11
Charleston	10	10	10
Pearl Harbor	4	- 3	15
Total	4	5	3

Table B-6

**DIRECT COSTS BY LABOR, MATERIAL, CONTRACTUAL AND OTHER
(Constant FY84\$)**

	FY79	FY80	FY81	FY82
	(\$000)			
<u>Norfolk</u>				
Labor	163,753	171,859	168,699	180,280
Material	92,867	95,012	97,566	120,190
Contractual	16,201	22,726	31,590	23,458
Other	14,472	13,113	3,603	4,000
Total	287,293	302,710	301,458	327,928
<u>Puget Sound</u>				
Labor	188,093	201,569	193,430	211,587
Material	79,469	73,350	83,408	90,847
Contractual	14,590	16,863	23,786	26,173
Other	8,727	8,212	3,452	2,553
Total	290,879	299,994	304,076	331,160
<u>Philadelphia</u>				
Labor	131,051	139,410	167,010	177,066
Material	53,583	62,988	69,480	95,707
Contractual	41,977	53,379	63,417	64,867
Other	2,082	4,913	2,786	4,535
Total	228,693	260,690	302,693	342,175
<u>Nare Island</u>				
Labor	164,407	167,716	183,482	196,650
Material	36,956	42,704	53,529	58,015
Contractual	19,334	14,929	17,177	17,196
Other	5,615	2,973	6,029	5,645
Total	226,312	228,322	260,217	277,506
<u>Portsmouth</u>				
Labor	109,304	114,721	119,305	123,350
Material	30,616	29,861	31,658	41,752
Contractual	11,147	12,165	18,389	20,899
Other	7,369	5,156	5,930	8,601
Total	158,436	161,903	175,282	194,602

Table B-6 continued
Direct Costs by Labor, Material, Contractual and Other
(Constant FY84\$)

			(\$000)		
		FY79	FY80	FY81	FY82
<u>Long Beach</u>					
- Labor		118,521	115,401	127,124	136,550
Material		54,330	55,200	63,944	89,254
Contractual		25,747	24,716	24,229	35,117
Other		6,562	2,332	4,444	7,360
Total		205,160	197,649	219,741	268,281
<u>Charleston</u>					
Labor		119,771	127,838	122,591	127,701
Material		48,709	50,153	53,574	53,154
Contractual		3,536	9,309	11,612	15,039
Other		1,499	2,826	4,585	3,428
Total		173,515	190,126	192,362	199,322
<u>Pearl Harbor</u>					
Labor		117,693	125,323	123,769	135,033
Material		47,209	48,140	52,172	51,416
Contractual		5,645	6,241	7,693	7,231
Other		1,504	703	893	2,138
Total		172,051	180,407	184,527	195,818
<u>Total</u>					
Labor		1,112,593	1,163,837	1,205,410	1,288,217
Material		443,739	457,408	505,331	600,335
Contractual		138,177	160,328	197,893	209,980
Other		47,830	40,228	31,722	38,260
Total		1,742,339	1,821,801	1,940,356	2,136,792

When comparing FY79 costs with FY82 costs by shipyard, costs generally were higher in FY82 than in FY79, but Norfolk and Puget Sound had decreases in the "other" category, while Mare Island had lower direct contract costs. Charleston, Portsmouth, Puget Sound, and Philadelphia all had growth rates over 50% for direct contract costs. Labor and material costs were higher at every shipyard.

Direct labor, material, and contractual costs per DLH varied between shipyards. Norfolk and Long Beach consistently had the highest constant dollar material costs per DLH, (\$9.97 at Long Beach in FY82); Mare Island and Portsmouth consistently had the lowest direct material costs per DLH, (\$4.59 at Portsmouth in FY82). The highest direct labor costs per DLH were consistently at Mare Island and Pearl Harbor, the lowest at Norfolk and Portsmouth. Contract costs per DLH were always very high at Philadelphia; relatively high at Long Beach, and extremely low at Pearl Harbor; \$5.15, \$3.92, and \$.91 respectively in FY82. The actual reasons for these contracting-out cost differences are not known, but one can surmise that contractor availability is low at Pearl Harbor. Since both non-nuclear yards consistently had high direct contract rates, shipyard practices and not the four year growth or change in workload probably explain the high rates. In fact, differences in location, practice, and workload are the only explanations that can be offered to explain the variations in direct cost components.

Indirect Costs by Labor, Material, Contractual, and Other

Indirect costs are shown by labor, material, contractual and other on Table B-7. For the eight shipyards, in constant dollars, the labor component of indirect costs grew 21% between FY79 and FY82 while indirect labor hours grew 22%, thus indirect labor costs per indirect labor hour fell. Indirect labor

Table B-7

INDIRECT COSTS BY LABOR, MATERIAL, CONTRACTUAL AND OTHER*
(Constant FY84\$)

	FY79	FY80	FY81	FY82
<u>Norfolk</u>				
Labor	125,859	130,877	141,610	155,293
Material	20,314	11,803	18,137	15,908
Contractual & Other	64,586	57,769	64,876	80,947
Total	210,759	200,449	224,623	252,148
<u>Puget Sound</u>				
Labor	130,311	138,599	141,039	146,750
Material	23,615	20,439	19,378	24,250
Contractual & Other	19,139	24,687	24,638	26,530
Total	173,065	183,725	185,055	197,530
<u>Philadelphia</u>				
Labor	84,763	96,553	110,599	126,443
Material	12,213	15,132	14,483	18,320
Contractual & Other	65,185	54,807	63,602	77,713
Total	162,161	166,492	188,684	222,476
<u>Nare Island</u>				
Labor	121,359	122,910	122,722	142,395
Material	12,185	10,381	12,600	17,052
Contractual & Other	41,179	40,615	37,467	43,568
Total	174,723	173,906	172,789	203,015

* Reimbursed costs are included in the total costs shown here, because they cannot be divided by labor, material, contractual and other.

Table B-7 continued
Indirect Costs by Labor, Material, Contractual and Other*
(Constant FY84\$)

	(\$000)			
	FY79	FY80	FY81	FY82
<u>Portsmouth</u>				
Labor	88,570	89,190	94,978	103,708
Material	12,734	13,136	9,559	15,329
Contractual & Other	25,045	31,692	32,148	36,204
Total	124,349	134,018	136,685	155,241
<u>Long Beach</u>				
Labor	77,849	80,634	83,401	84,647
Material	14,194	12,605	12,376	13,076
Contractual & Other	42,348	33,981	31,143	41,677
Total	134,391	127,220	126,920	139,400
<u>Charleston</u>				
Labor	92,977	96,859	101,246	104,491
Material	13,454	13,928	10,454	16,396
Contractual & Other	34,806	39,253	34,246	41,505
Total	141,237	150,040	145,946	162,392
<u>Pearl Harbor</u>				
Labor	76,379	87,853	88,188	100,933
Material	8,571	10,983	4,874	13,173
Contractual & Other	27,952	28,298	28,137	38,009
Total	112,902	124,137	121,199	152,115
<u>Total</u>				
Labor	796,067	840,478	883,783	964,660
Material	117,280	108,407	101,861	133,504
Contractual & Other	320,240	311,102	316,257	386,153
Total	1,233,587	1,259,987	1,301,901	1,484,317

costs grew fastest at Philadelphia and Pearl Harbor. In total constant dollar material costs fell every year except FY82, which is consistent with the change in funding for depot level reparable material. The G&A portion of actual material costs varied and was sometimes negative due to the sale of salvage materials and other adjustments. This caused some of the fluctuation in constant dollar material costs. At Norfolk and Long Beach, constant dollar material costs declined over the four years, while at Pearl Harbor and Philadelphia they increased at least fifty percent. Contract and other costs grew 21% in constant dollars between FY79 and FY82, and rose at every shipyard except Long Beach. Portsmouth, Puget Sound and Pearl Harbor had the largest rate of increase in contract and other costs.

In terms of costs per DLH, Mare Island had the highest labor costs in FY79 and FY80, but in the other two years that distinction belonged to Charleston and Pearl Harbor, the smallest shipyards. Philadelphia usually had the lowest indirect labor costs per DLH, (\$10.04 in FY82) but the highest DLH costs for indirect contract and other (\$6.17 in FY82). Puget Sound always had the lowest indirect contract and other costs per DLH, (\$1.97 in FY82). Material costs per DLH varied by year and shipyard.

Indirect Costs by Production, Manufacturing, and General and Administrative

As shown in Table B-8, manufacturing was the fastest growing indirect component for the combined shipyards and for five individual activities. Although the manufacturing portion of indirect costs grew 30% in constant dollars for all Naval shipyards between FY79 and FY82, the percentage increases at individual shipyards varied from 18% to 79%. Philadelphia's 79% increase in manufacturing costs was double the next highest growth rate of 38% at Pearl Harbor.

Table B-8
INDIRECT COSTS BY PRODUCTION, MANUFACTURING, AND
GENERAL AND ADMINISTRATIVE
(Constant FY84 \$)

			\$000		% Increase FY79-FY82
	FY79	FY80	FY81	FY82	
<u>Norfolk</u>					
Production	79,206	77,301	84,047	96,723	22%
Manufacturing	57,180	56,335	51,578	67,497	18%
G&A	66,160	62,387	84,486	83,167	26%
Total	202,546	196,023	220,111	247,387	22%
<u>Puget Sound</u>					
Production	83,785	86,556	84,924	89,154	6%
Manufacturing	49,411	49,496	52,908	60,511	23%
G&A	38,080	42,332	41,545	42,882	13%
Total	171,276	178,384	179,377	192,547	12%
<u>Philadelphia</u>					
Production	47,582	52,784	59,895	74,326	56%
Manufacturing	28,961	34,333	37,096	51,698	79%
G&A	65,809	61,164	73,476	77,523	18%
Total	142,352	148,281	170,467	203,547	43%
<u>Mare Island</u>					
Production	72,076	68,925	69,249	86,921	21%
Manufacturing	40,611	40,436	39,675	49,818	23%
G&A	59,055	60,327	59,129	57,625	-2%
Total	171,742	169,688	168,053	194,364	13%

Costs reported in Financial and Operating Statements Exhibit H, Summary of Operating Expenses, after the transfer of power costs from G&A to the production and manufacturing expense centers and after the reimbursement of applicable expenses.

Table B-8 continued
Indirect Costs by Production, Manufacturing, and
General and Administrative
(Constant FY84 \$)

			\$000		% Increase FY79-FY82
	FY79	FY80	FY81	FY82	
<u>Portsmouth</u>					
Production	49,736	49,246	51,449	59,479	20%
Manufacturing	34,845	35,267	39,978	42,721	23%
G&A	37,186	45,195	40,981	47,974	29%
Total	121,767	129,708	132,408	150,174	23%
<u>Long Beach</u>					
Production	46,646	46,110	46,692	48,352	4%
Manufacturing	30,029	27,118	29,935	37,920	26%
G&A	52,055	50,168	46,621	46,870	-10%
Total	128,730	123,396	123,248	133,142	3%
<u>Charleston</u>					
Production	48,934	48,645	47,460	50,593	3%
Manufacturing	37,795	41,696	44,263	50,020	32%
G&A	39,770	45,097	37,687	44,338	12%
Total	126,499	135,438	129,410	144,951	15%
<u>Pearl Harbor</u>					
Production	42,858	48,608	51,462	59,678	39%
Manufacturing	32,175	32,257	30,572	44,399	38%
G&A	37,407	42,643	38,612	46,781	25%
Total	112,440	123,508	120,646	150,858	34%
<u>Total</u>					
Production	470,823	478,175	495,178	565,226	20%
Manufacturing	311,007	316,938	326,005	404,584	30%
G&A	395,522	409,313	422,537	447,160	13%
Total	1,177,352	1,204,426	1,243,720	1,416,970	20%

Philadelphia and Pearl Harbor also had the fastest growth in production overhead, 56% and 39% respectively. At half the shipyards the rates of growth for production and manufacturing costs were fairly even; but at Philadelphia, Puget Sound, Long Beach and Charleston, manufacturing costs grew significantly faster.

G&A overhead increased 13% for all shipyards but individual growth varied from -10% to 29%. Norfolk, Portsmouth, and Pearl Harbor had the fastest growth while constant dollar costs fell at Long Beach and Mare Island.

It is the Navy's practice to distribute indirect costs by direct labor hours. Manufacturing overhead is prorated to the production and other production cost centers on the basis of direct labor hours. Following that, the combined indirect manufacturing and production costs for each expense center are divided by the applicable direct production labor hours, resulting in production overhead rates which are only applied to specific production centers. General and Administrative costs are divided by total direct labor hours and this G&A rate is applied to all direct labor hours. Sometimes the production and G&A rates are combined and referred to as a composite overhead rate. It should be noted that the rates reported in the Financial and Operating Statements were not always computed in the correct or a like manner. The differences were in the treatment of direct manufacturing hours, which should not be part of the production rate calculation, and the inclusion or exclusion of process labor hours. Manufacturing costs were charged as part of G&A in FY79, but the figures used in this analysis were adjusted to be consistent with other fiscal years.

Figures B-1 and B-2 are graphs of constant dollar production and G&A overhead rates for each shipyard. The rates are listed in Table 9. In total and at five shipyards, the production rate increased between FY79 and FY82. The three exceptions, Puget Sound, Mare Island, and Long Beach, are all west coast

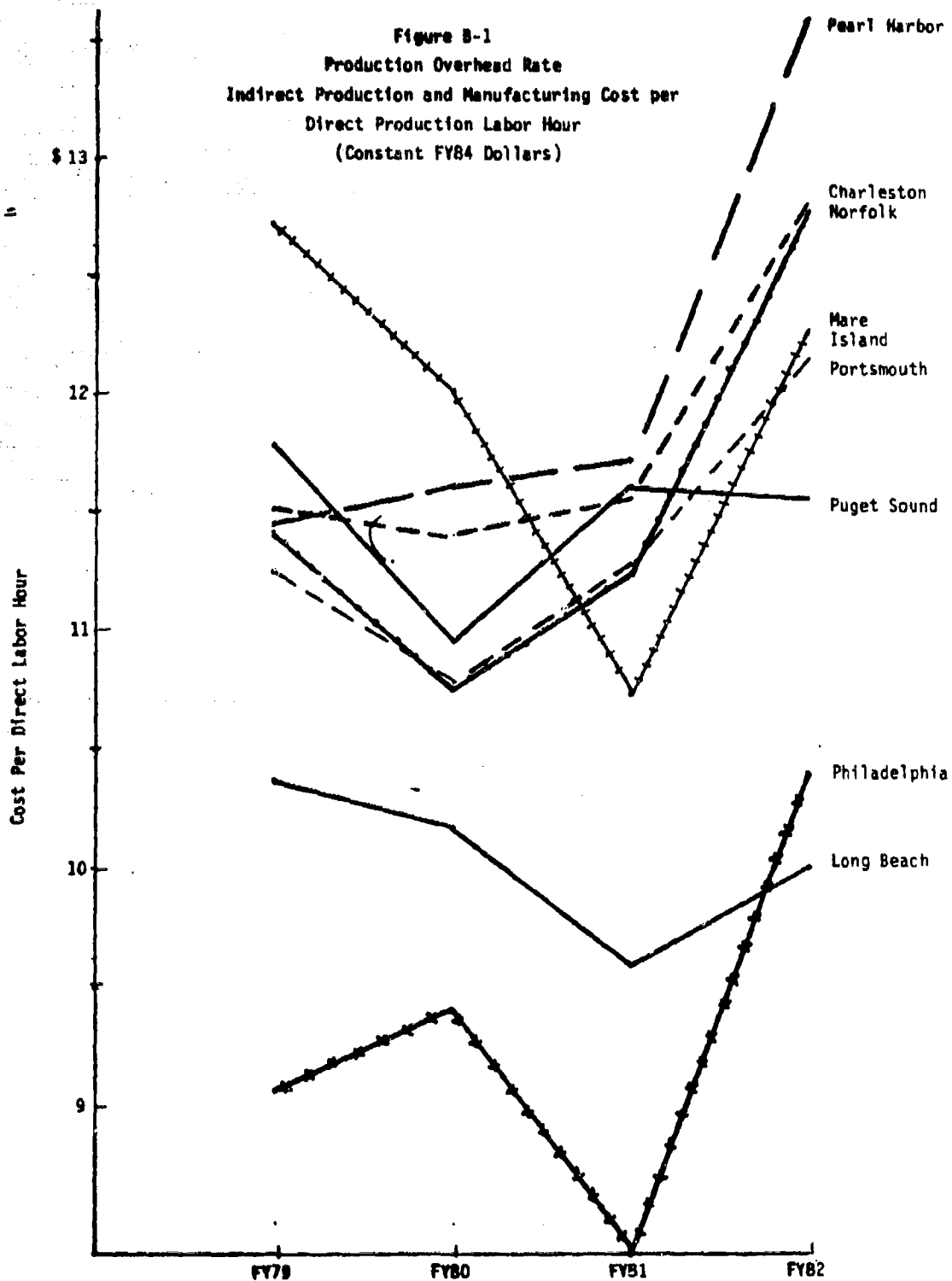


Figure B-2
 General and Administrative Overhead Rate
 Indirect General and Administrative Cost per Direct Labor Hour
 (Constant FY84 Dollars)

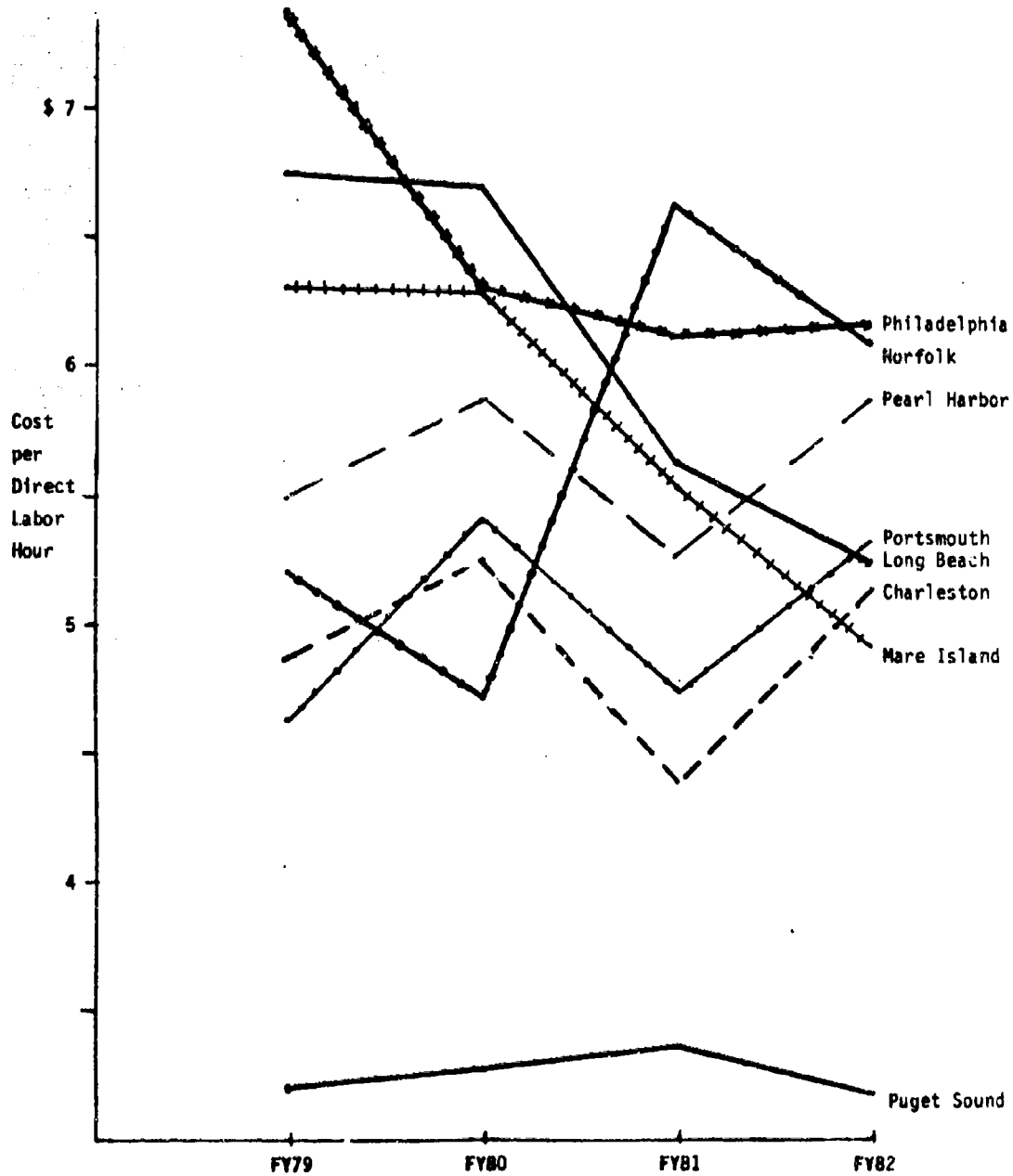


Table 8-9

PRODUCTION AND GENERAL AND ADMINISTRATIVE OVERHEAD RATES
(Constant FY84 Dollars)

	FY79	FY80	FY81	FY82
<u>Production Overhead Rate</u>				
Norfolk	\$11.42	\$10.75	\$11.23	\$12.78
Puget Sound	11.79	10.95	11.60	11.56
Philadelphia	9.06	9.39	8.39	10.40
Mare Island	12.72	12.02	10.73	12.27
Portsmouth	11.25	10.78	11.30	12.14
Long Beach	10.36	10.16	9.59	10.00
Charleston	11.52	11.40	11.57	12.82
Pearl Harbor	11.45	11.60	11.72	13.60
<u>General and Administrative Overhead Rate</u>				
Norfolk	\$5.20	\$4.72	\$6.61	\$6.08
Puget Sound	3.20	3.28	3.36	3.19
Philadelphia	7.39	6.31	6.12	6.16
Mare Island	6.31	6.29	5.54	4.91
Portsmouth	4.62	5.41	4.74	5.31
Long Beach	6.76	6.70	5.63	5.24
Charleston	4.86	5.25	4.39	5.16
Pearl Harbor	5.49	5.86	5.27	5.86

shipyards. Pearl Harbor and Philadelphia had the largest percentage increase in production overhead rates, but Pearl Harbor consistently had high production overhead rates and Philadelphia usually had the lowest.

Between FY79 and FY82, G&A rates fell in total and at half the shipyards. Puget Sound, Mare Island and Long Beach again had decreasing rates (22% at the latter two), but so did Philadelphia, which had the largest increase in direct labor hours. Even though Philadelphia's G&A rate dropped over the four years, it was consistently one of the most expensive. Long Beach had a relatively high G&A rate in FY79 and FY80 and Norfolk's was high in the two later years. Puget Sound's G&A rate was exceptionally low, due to low utility and maintenance costs, both of which were about half that of Norfolk, which had a similar amount of direct labor hours.

As mentioned in the text, if G&A costs are relatively fixed, then costs per DLH would vary inversely with direct labor hours. This was true at Norfolk and Mare Island and partially true at Philadelphia and Long Beach. At Charleston and Pearl Harbor the G&A rate tended to follow the same growth pattern as direct labor hours. Puget Sound's rate was relatively steady despite labor hour variations, and Portsmouth's G&A rate varied widely despite a steady increase in direct labor hours. Therefore, the expected fixed and non discretionary nature of G&A costs must be questioned.

Indirect General and Administrative Expense Centers

Because of the diversity and interest in G&A costs, this section examines the behavior of the individual expense centers that make up G&A overhead. Table B-10 presents these costs totalled for all shipyards. The costs used here had reimbursements deducted but unlike the previous section on production, manufac-

Table B-10

TOTAL GENERAL AND ADMINISTRATIVE INDIRECT COSTS BY EXPENSE CENTER
(Actual Dollars)

	\$000				\$ Increase
Program	FY79	FY80	FY81	FY82	FY79-FY82
<u>Expense Center</u>					
Safety	1,916	3,372	6,089	7,930	314%
EEO	-	1,750	1,777	2,020	-
Data Processing	18,729	21,688	26,119	35,405	89%
Industrial Relations	17,709	21,897	28,794	27,077	53%
Shipyards General	45,700	47,321	51,269	62,935	38%
Public Works - Office	18,730	22,260	25,912	28,980	55%
Public Works - Transportation	42,740	47,746	51,194	60,783	42%
Public Works - Utilities	74,915	100,659	123,947	134,211	79%
Public Works - Maintenance	48,913	51,638	52,524	61,604	26%
Supply	42,848	49,507	56,542	64,962	52%
Comptroller	10,681	11,664	13,344	14,804	39%
Administration	26,585	27,718	31,042	37,550	41%
Other *	3,292	6,703	9,263	17,139	-
Total	352,758	413,923	477,816	555,400	57%

Costs Reported in Financial and Operating Statements Exhibit H, Summary of Operating Expenses, after the reimbursement of applicable expenses.

* Includes Shipyards Commander, Management Engineering, and Video Production Expense Centers

turing and G&A, power costs remained in the G&A utilities expense center. This explains why utilities was almost always the largest G&A component. In actual FY82 dollars, public works/utilities comprised 24% of G&A, public works/maintenance made up 12%, and shipyard general, supply and public works/transportation each accounted for 11%. These were also the largest expense centers in FY79. The four public works centers; public works office, transportation, utilities, and maintenance, were 51% of all FY79 G&A costs and 53% of all FY82 costs. In FY82, administration composed 7% of total G&A, industrial relations 5%, and comptroller 3%. Data processing, the fastest growing expense center had 6% of all FY82 G&A costs.

Data processing and utilities had the fastest four year growth, 89% and 79% respectively. Safety costs actually grew 314% over the four years but that expense was such a small part of total G&A, 1% in FY82, that it was not considered to be the fastest growing component. Although the reported G&A costs for safety and EEO, the "social" programs often cited as reasons for rising expenses, only increased \$8 million between FY79 and FY82; these costs exclude OSHA and pollution maintenance costs charged as production and manufacturing overhead.

G&A maintenance costs had the smallest percentage growth, but that expense center only accounted for 20% of total indirect maintenance costs. In actual dollars, total maintenance related costs increased 57% over the four years; facilities maintenance grew 74% and equipment maintenance grew 48%. OSHA maintenance, primarily repairs and alterations, increased \$3 million over the four years; OSHA costs made up 1% of total maintenance costs in FY79 and FY82.

Indirect Significant Program Costs

Significant program cost per DLH trends for the combined shipyards showed a decrease in recurring maintenance, 4-5% increases in non-supervisory and supervisory labor, an 11% rise in utilities and greater than 20% increases in training and MNRM. Individual shipyard cost per DLH trends and relationships, which are shown in Figures B-3 through B-10, vary from this overall behavior.

At most shipyards in most years, non-supervisory labor was the most expensive program. The exceptions were FY80 at Portsmouth, where constant dollar non-supervisory costs dropped for one year, FY79 and FY80 at Puget Sound, and all four years at Mare Island. Mare Island did have the highest supervisory costs per DLH which may be explained by wage rates in that region or by the fact that Mare's diverse workload requires more supervisory management. Philadelphia and Long Beach, the non-nuclear shipyards, had some of the lowest supervisory costs which would be expected given the supervisory ratio difference between nuclear and non-nuclear work. At individual shipyards, supervisory and non-supervisory costs per DLH usually followed the same trends, with more gradual changes in supervisory costs. Mare Island and Long Beach had costs per DLH decline for both the supervision and non-supervision labor programs, Norfolk had the largest percentage increase in those programs.

Costs per DLH for utilities in FY82 were higher than in FY79 at every shipyard except Norfolk and Mare Island. The largest growth in utilities cost per DLH was at Puget Sound and Charleston. Philadelphia reported the highest cost utilities per DLH and Puget Sound and Mare Island were low.

Training costs per DLH rose more than 8% at every shipyard. The largest growth, a 69% increase over four years, occurred at Pearl Harbor. Mare Island had the highest training cost per DLH in FY79 and FY80 and Norfolk had the highest costs in FY81 and FY82.

Recurring maintenance costs per DLH were always higher than MNRM. Over the four years studied, recurring maintenance costs per DLH stayed the same or dropped at each shipyard except Norfolk, Charleston and Pearl Harbor. At Norfolk this FY82 cost increased 32% over an FY81 cost which was already relatively high. Generally, there was no consistent relationship between constant dollar recurring maintenance costs and changes in the number of direct labor hours. Puget Sound had relatively stable and the lowest recurring and major non-recurring maintenance costs.

Major non-recurring maintenance costs grew faster than recurring maintenance costs, with total constant dollar increases of 41% and 13%, respectively, over the four years. MNRM per DLH costs varied from year to year at most individual shipyards. There is validity to the question of whether major maintenance is a short term function of the number of direct labor hours, but that cost per DLH ratio was used here to be consistent with the treatment of other program costs. Comparing FY79 and FY82 MNRM costs per DLH shows the same rate at Pearl Harbor, a lower rate at Long Beach, and a significantly lower rate at Philadelphia, which had a very high rate in FY79. Norfolk's MNRM costs doubled over the four years.

The MNRM growth was affected by the charging of large accruals at four shipyards. Accruing maintenance expenses for work not yet begun was disallowed beginning in FY83, so the effect of this accounting policy change on maintenance costs is not yet known. In a related vein, it should also be noted that shipyards will no longer receive direct appropriations for capital equipment investment. In the future resources required for this investment will come from revenues received; hence, shipyard rate structures must include allowances for capital equipment investment.

Figure B-3
Norfolk
Indirect Significant Program Costs per Direct Labor Hour
(Constant FY84 Dollars)

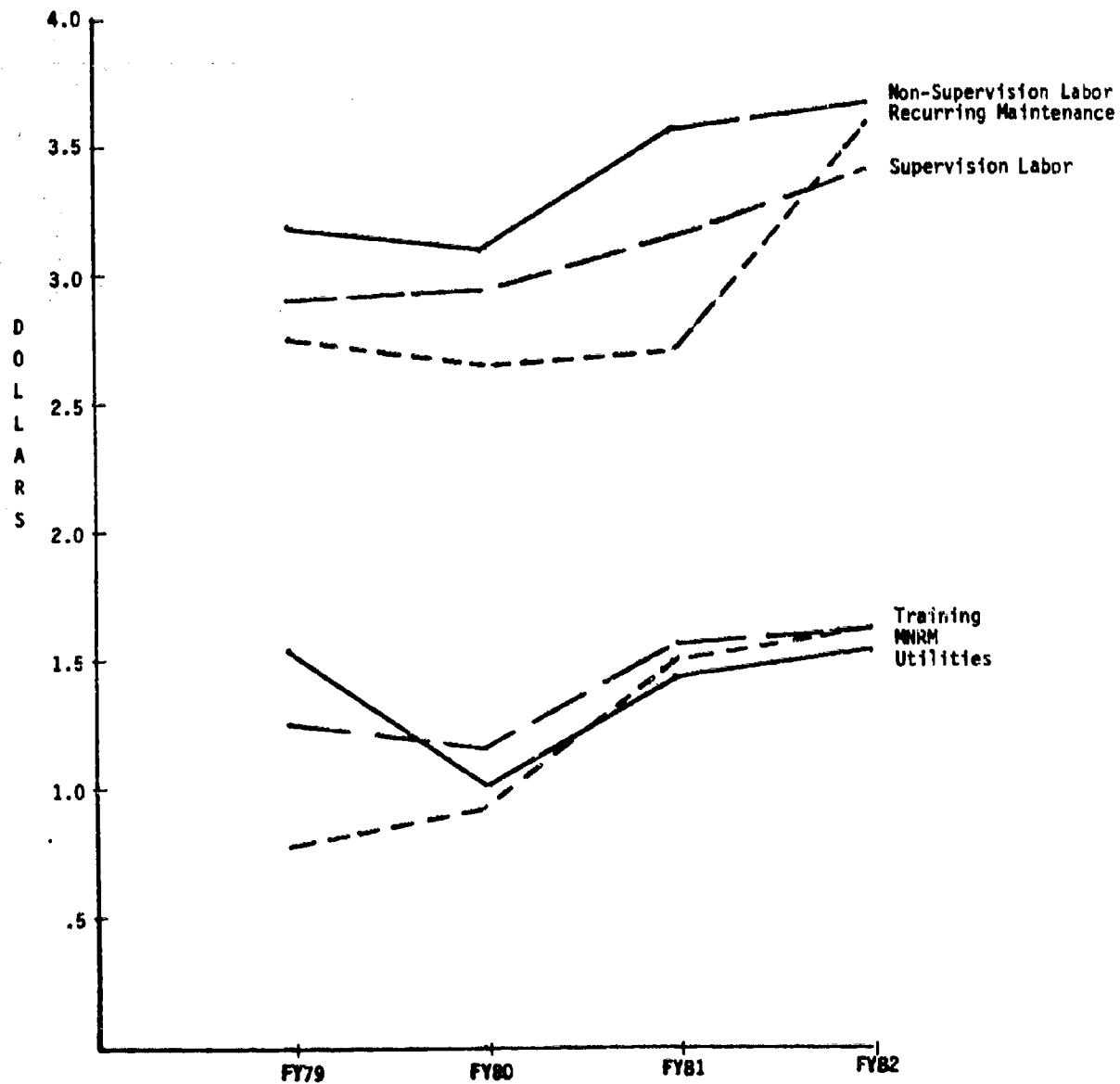


Figure B-4
Puget Sound
Indirect Significant Program Costs per Direct Labor Hour
(Constant FY84 Dollars)

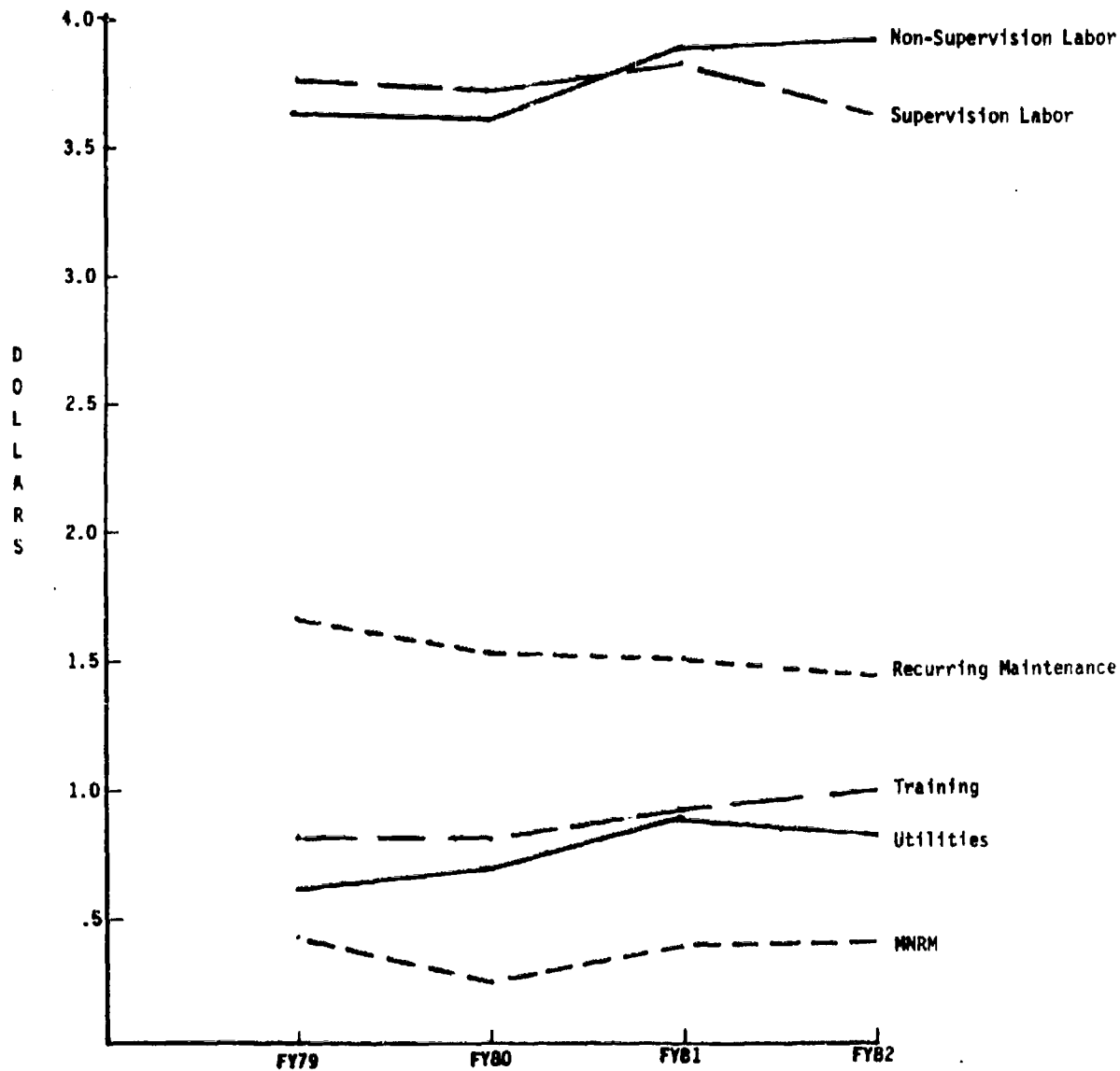


Figure B-5
Philadelphia
Indirect Significant Program Costs Per Direct Labor Hour
(Constant FY84 Dollars)

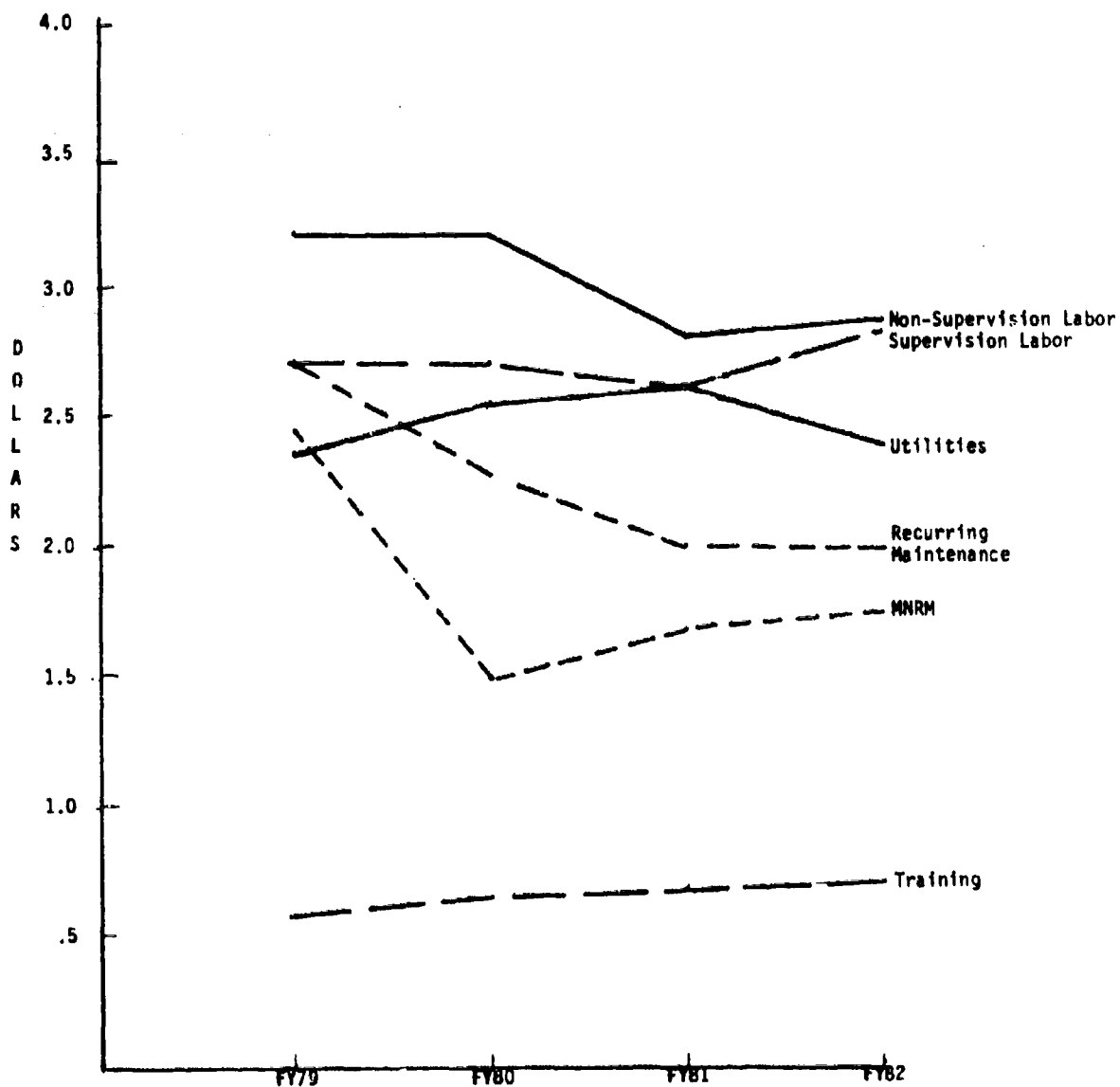


Figure B-6
 Mare Island
 Indirect Significant Program Costs Per Direct Labor Hour
 (Constant FY84 Dollars)

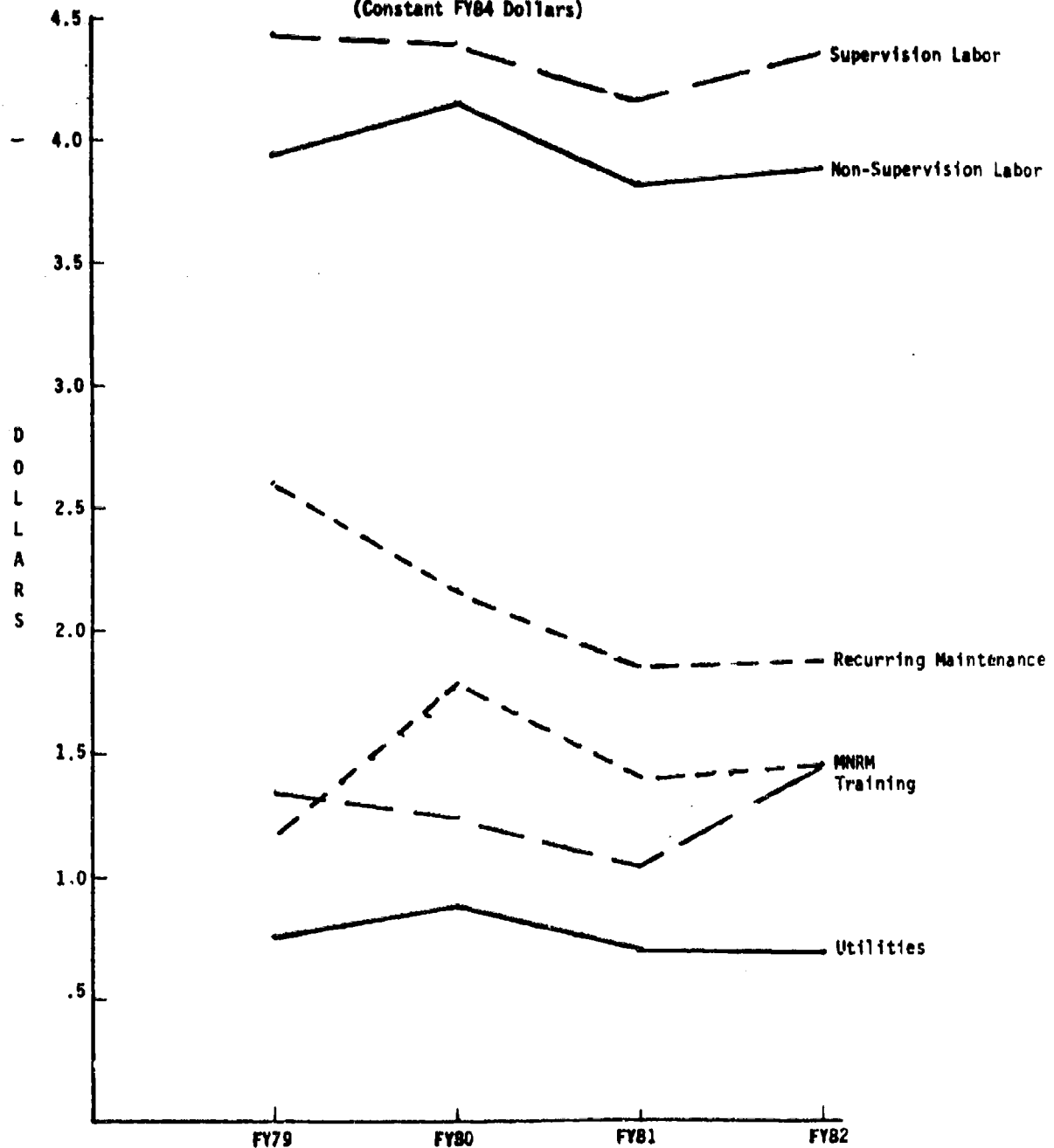


Figure B-7
 Portsmouth
 Indirect Significant Program Costs per Direct Labor Hour
 (Constant FY84 Dollars)

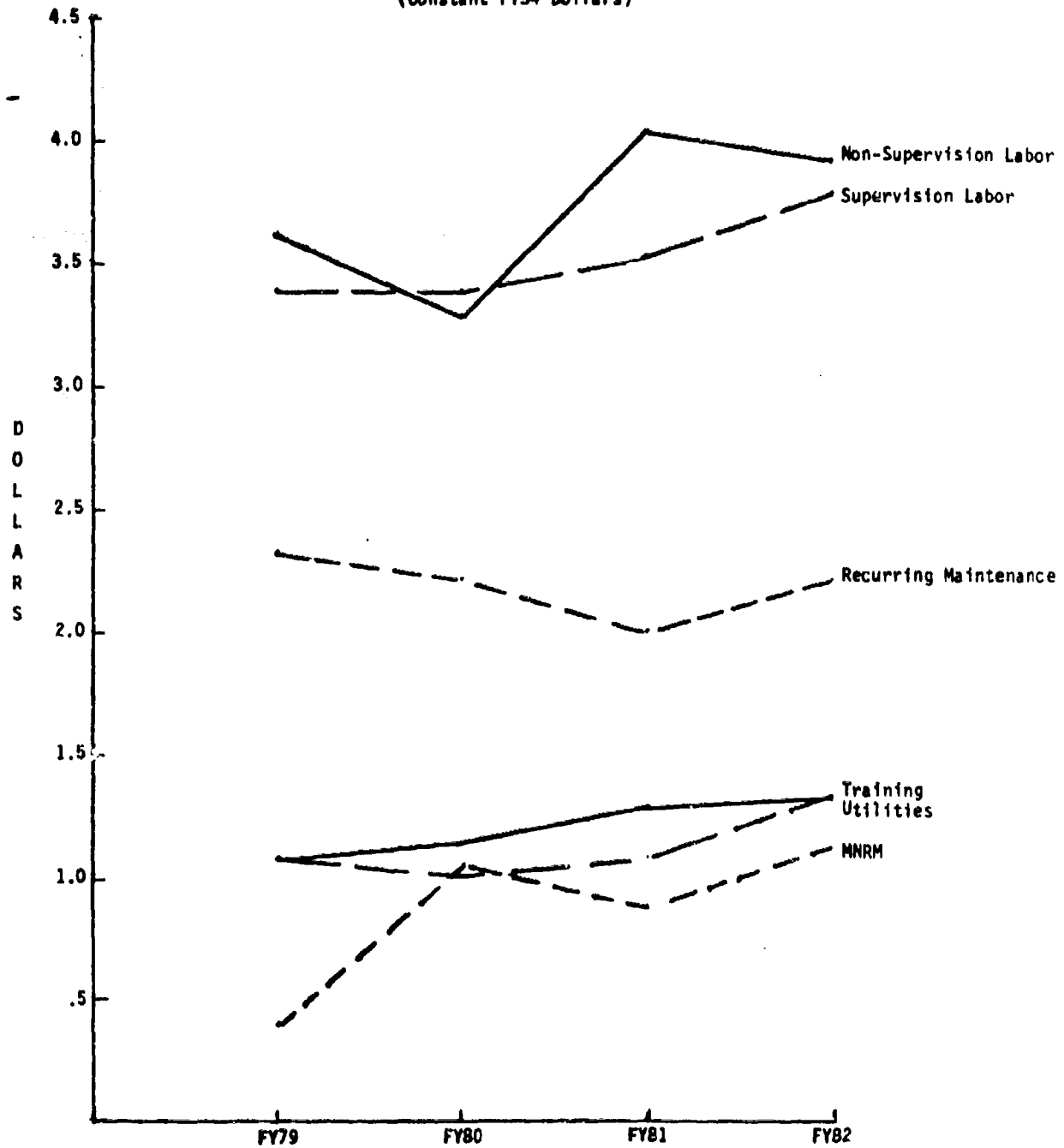


Figure B-8
Long Beach
Indirect Significant Program Costs per Direct Labor Hour
(Constant FY84 Dollars)

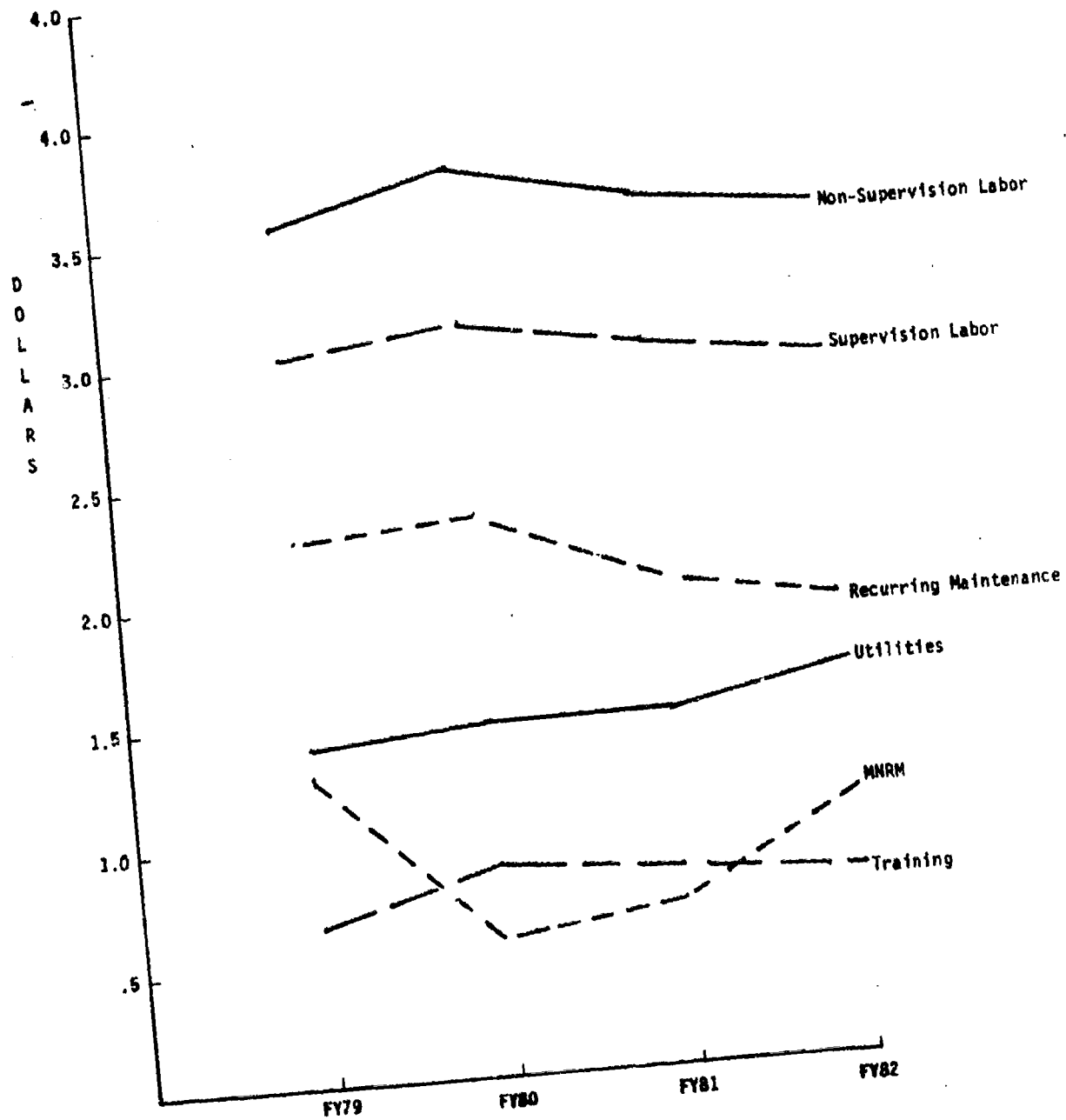


Figure B-9
 Charleston
 Indirect Significant Program Costs per Direct Labor Hour
 (Constant FY84 Dollars)

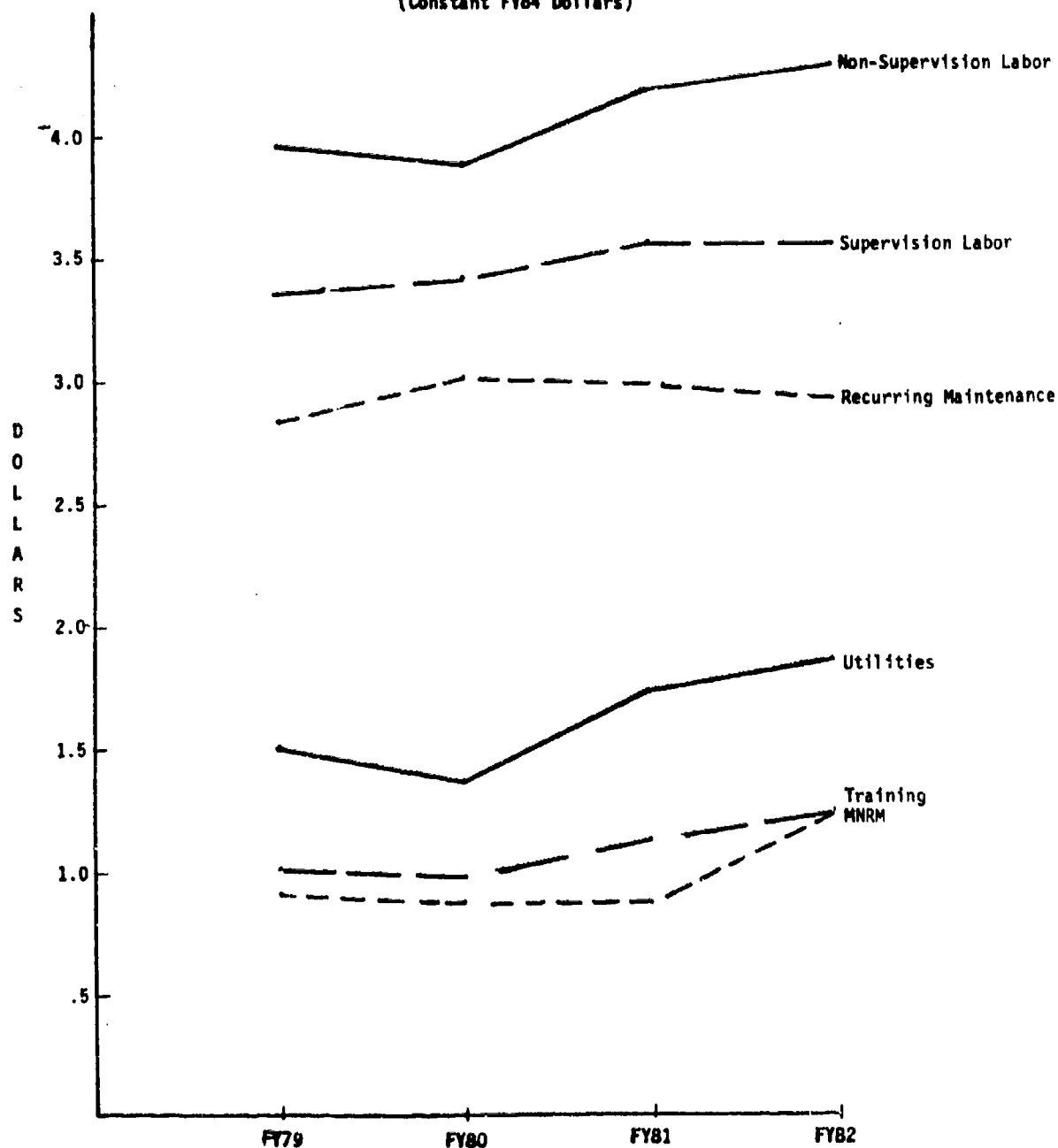


Figure B-10
 Pearl Harbor
 Indirect Significant Program Costs Per Direct Labor Hour
 (Constant FY84 Dollars)

