PERFORMANCE AUDIT

DEPARTMENT OF TRANSPORTATION

CONSTRUCTION MANAGEMENT

Report to the Arizona Legislature
By the Auditor General
October 1987
87-11

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October 30, 1987

Members of the Arizona Legislature
The Honorable Evan Mecham, Governor
Mr. Charles L. Miller, Director
Arizona Department of Transportation

Transmitted herewith is a report of the Auditor General, A Performance Audit of the Arizona Department of Transportation, construction management function. This report is in response to a July 26, 1985, resolution of the Joint Legislative Oversight Committee.

The report addresses two areas in which ADOT can improve its construction staff management. We found that ADOT has not adequately controlled construction staffing levels, resulting in overstaffing that has cost the state an estimated $7.4 million over the last four years. In addition, ADOT's Construction Engineering Manpower Management System--which was designed to help control construction staffing levels--is not being utilized effectively and needs greater management support.

My staff and I will be pleased to discuss or clarify items in the report.

Respectfully submitted,

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SUMMARY

The Office of the Auditor General has conducted a performance audit of the Arizona Department of Transportation (ADOT), construction management function in response to a July 26, 1985, resolution of the Joint Legislative Oversight Committee. This performance audit is one in a series of audits on ADOT and was conducted as part of the Sunset Review set forth in Arizona Revised Statutes §§41-2351 through 41-2379.

ADOT oversees highway construction of all interstate, primary and secondary roadways to ensure that specifications are met and that contractors fulfill their legal obligations. To perform the oversight function, ADOT has approximately 600 construction staff located throughout the State. In recent years, ADOT has also contracted with private sector engineering consulting firms to provide oversight on some projects.

ADOT Has Not Adequately Controlled Construction Staffing Levels, Resulting In Overstaffing That Has Cost The State An Estimated $7.4 Million Over The Last Four Fiscal Years (see pages 9 through 26)

Over the last four years ADOT has overstaffed its construction function by 21 to 101 unnecessary staff annually, costing the State approximately $7.4 million. Our estimate of overstaffing is based on analysis of data on three variables: 1) construction engineering (CE) costs, 2) the substantial variations in staff productivity, and 3) excessive amounts of non construction time charged by staff.

Our estimates were further supported by Auditor General staff field visits to construction orgs and ADOT's own field reviews which provided several examples of overstaffing.

- A District Two official acknowledges his district will be overstaffed by an average of 44 employees over the next 12 months.
- District Four maintains a permanent construction staff (averaging approximately 70 staff) year-round, although construction activities vary during the year due to climatic conditions. As a result, one resident engineer stated his org was overstaffed from eight to 14 positions for nine months of the year. Further, ADOT field reviews recently reported a surplus of 22 out of an average of 47 staff in two District Four orgs.

- ADOT field reviews also found significant amounts of excess hours charged to the survey function for several projects. ADOT found one project's survey charges overrunning estimates by 240 to 315 percent. Another project overran estimates by 6,000 hours. Central office staff attributed the overruns to staff charging excess time to this function.

ADOT's construction program will expand in three of the next five years. Before increasing staff size, ADOT should first consider making more use of consultant engineers, contracting out more of the construction engineering functions (such as surveying) and making better use of its own staff resources. These actions will help prevent staffing for peak workloads and the resultant overstaffing once the peaks have passed.

Because ADOT has failed to properly adjust past staffing levels to meet fluctuations in workload, we recommend that the Legislature consider setting and monitoring construction staffing levels, as is done in several other states. We also recommend a follow-up performance audit in two years to review ADOT's progress in managing construction staff size.

ADOT'S Construction Engineering Manpower Management System Is Not Being Utilized Effectively And Needs Greater Management Support (see pages 27 through 36)

ADOT has not effectively used its construction engineering manpower management system (CEMMS) to adjust staffing levels based on workload. CEMMS was implemented in October 1982 to provide construction managers with tools to plan, schedule and control construction engineering personnel and costs.

We found, however, that despite the $550,000 ADOT has committed to CEMMS since 1982, CEMMS is not being effectively utilized to manage CE resources.

- ADOT has not effectively used CEMMS' long-range labor planning and short-range project staffing functions to ensure that staffing levels are appropriate.
- The CEMMS budget function is not well understood or used by district personnel.

- ADOT has misused the CEMMS scheduling function, which if used properly, assesses short-term staffing needs and plans for efficient personnel use. For example, resident engineers have, in some cases, overstated staffing needs.

- CEMMS reports identifying ADOT construction engineering hours and cost overruns are not received by nearly half of the construction orgs. Some districts have stopped distribution of the reports. Without feedback, action cannot be taken to control costs. District personnel stated that even when problem projects are identified, little or no formal action is taken.

Although repeatedly informed of problems with CEMMS, ADOT management has taken little action to correct deficiencies or ensure system utilization. Problems with management direction, adequate district staff commitment, system analyses and updating and training have been reported to ADOT management regularly over the last five years by outside consultants and ADOT staff. ADOT upper management needs to make a firm commitment to address the problems with its manpower management system to ensure that ADOT uses its staff and other resources efficiently and effectively.

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INTRODUCTION AND BACKGROUND

The Office of the Auditor General has conducted a performance audit of the Arizona Department of Transportation (ADOT) in response to a July 26, 1985, resolution of the Joint Legislative Oversight Committee. This performance audit was conducted as part of the Sunset Review set forth in Arizona Revised Statutes §§41-2351 through 41-2379.

This is the fifth in a series of reports to be issued on the Arizona Department of Transportation. This report focuses on the management of Arizona's highway construction program.

Construction Management Responsibilities

The Arizona Department of Transportation's Highways Division is responsible for the construction of all interstate, primary and secondary roadways in the State's highway system. There are two major groups within this Division: Highway Development and Highway Operations. The Highway Development Group has responsibility for roadway design and acquiring the land needed for construction of these roads. Highway Operations, which is the focus of this audit, is responsible for coordination, management and oversight of all construction to ensure that it meets specifications and that contractors fulfill their contractual obligations.[1] Given the cost of road construction, this function is critical to ensure that roads are of sufficient quality to meet their intended design life.

Several specific activities comprise the Highway Operations Group's responsibilities. Under the general category of construction engineering, these responsibilities include:

- Inspection and materials testing of all roadway construction to ensure that procedures and materials meet plans and specifications.

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(1) All road construction is performed by private contractors selected through a competitive bidding process.

- Surveying activities (over and above those performed by the contractor) necessary for effective control of construction operations.
- Reviewing roadway design drawings.
- Taking measurements of estimated work completed for preparation of payments made to contractors.
- Reviewing, monitoring and processing claims, change orders and force accounts.

Most of these activities are the responsibility of ADOT's own personnel. However, since fiscal year 1983-84 ADOT has contracted with engineering consulting firms to perform construction engineering activities for a limited number of construction projects. While the number of these contracts has been minimal, the size of some construction projects on which consultants have been utilized is large. During fiscal year 1986-87, consultants performed project oversight and inspection functions for approximately 25 percent of the program dollars spent on actual road construction.

Organization And Staffing

Within the Highway Operations Group, management of road construction projects is the responsibility of the four engineering districts (see Figure 1), with technical support provided by the Materials and Construction Sections located in ADOT's central office. Figure 2 shows how ADOT is organized to carry out its construction engineering responsibilities. All construction related activities within these engineering districts are the responsibility of the district engineer. Actual day-to-day operations are delegated to the deputy district engineer.

FIGURE 1

ADOT ENGINEERING DISTRICTS

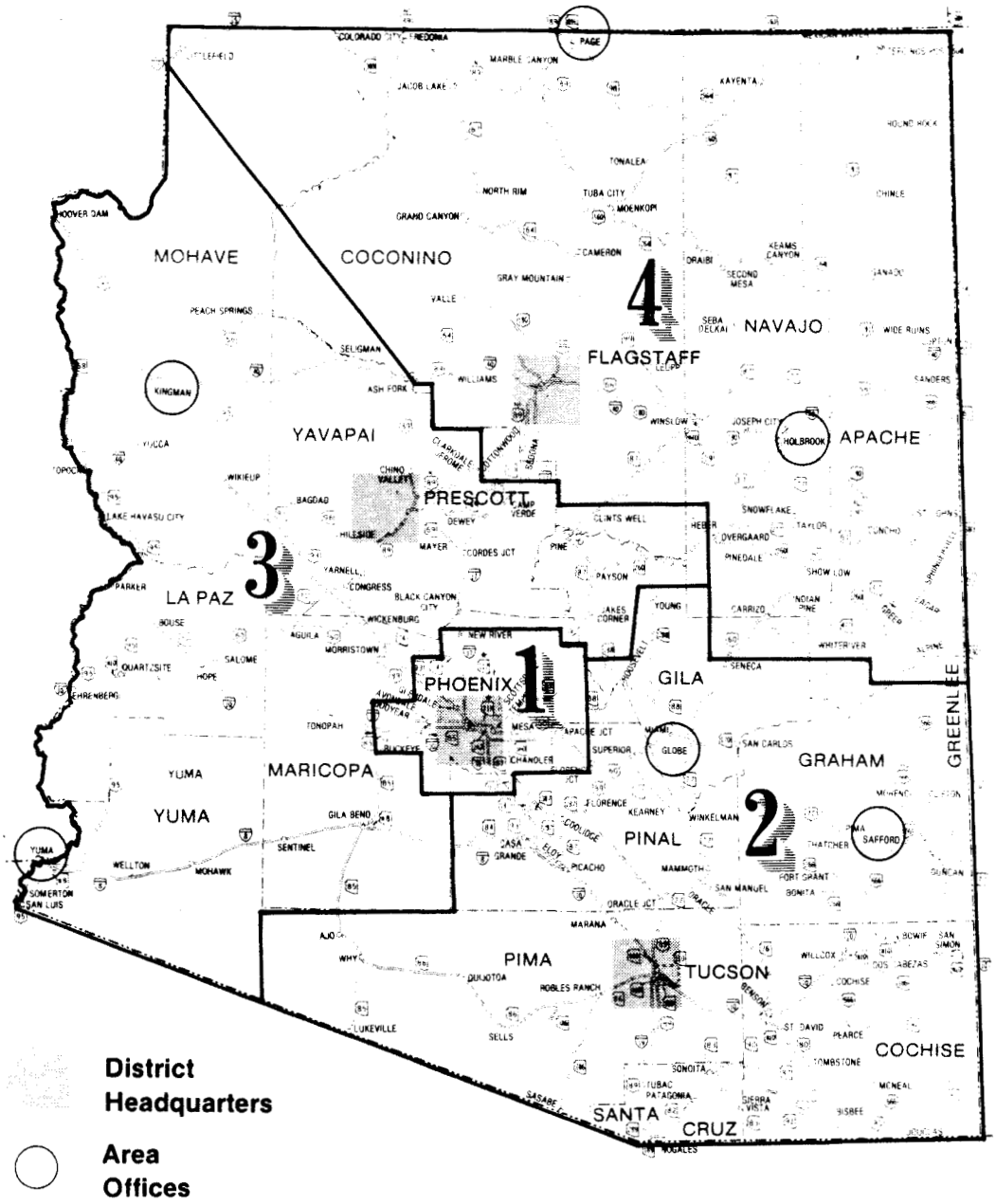
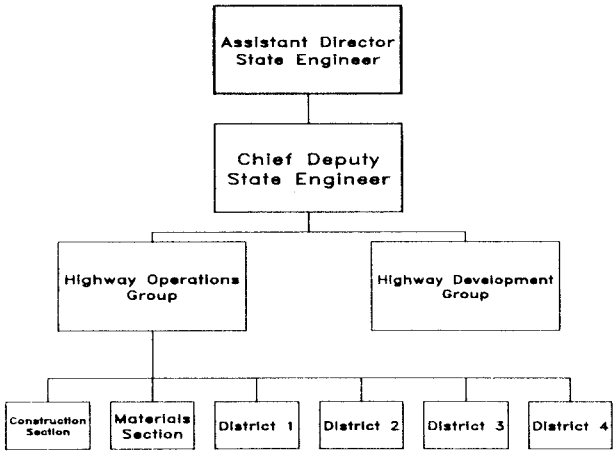
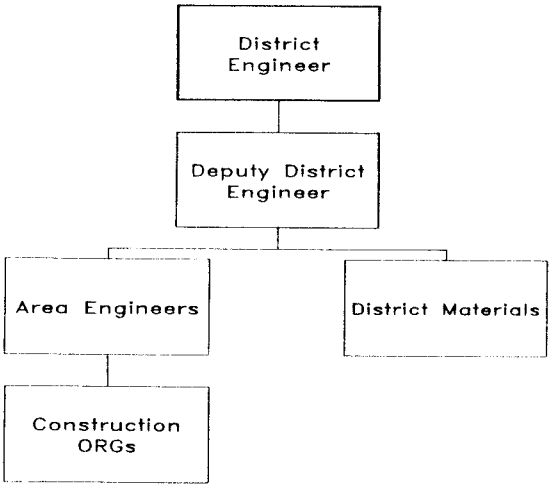


FIGURE 2

HIGHWAYS DIVISION ORGANIZATIONAL CHART





Source: ADOT Construction Manual.

Because of the large geographical areas encompassed, engineering districts are further divided into three or more area jurisdictions. Each of these is headed by an area engineer. Area engineers are responsible for all highway construction within their respective geographical boundaries.

Construction personnel are assigned to construction or materials testing units (orgs). ADOT's construction orgs, under the supervision of a resident engineer, are responsible for the day-to-day field coordination and management (construction engineering) of various construction projects assigned to them.

ADOT's Materials and Construction Sections in the central office provide the districts with technical support in fulfillment of these construction management responsibilities. The Materials Section develops test methods, acts as the reference laboratory for district and project laboratories, and performs tests that cannot be conducted by the other labs. The Materials Section also monitors tests performed by project and district labs to ensure uniform test results. The Construction Section is responsible for quality control site inspections and maintaining the Division's Construction Engineering Manpower Management System. This Section also audits and processes contractor payments and manages all paperwork pertaining to contractor claims.

The majority of ADOT personnel involved in the coordination and management of highway construction projects are located in the four engineering districts. There are approximately 600 permanent construction full-time equivalent (FTE) positions assigned to these districts. Another 128 FTEs are assigned to the Highways Division and Highway Operations central office administration, and to the Materials and Construction Sections.

Revenues And Expenditures

Funds for Arizona's highway construction program come from a variety of Federal and State sources, including gasoline and sales taxes. The majority of Arizona's share of Federal highway funds is earmarked for completion, improvement and preservation of the interstate highway system.

Federal funds are still a major funding source for the highway construction program, expected to total $644 million over the next five years. However, the Federal share has declined significantly in recent years and represents just 22 percent of the funds allocated to the program from fiscal year 1987-88 through fiscal year 1991-92. This contrasts significantly with prior years when the Federal share averaged approximately 67 percent of total funds allocated.

Approximately 77 percent ($2.27 billion) of the highway construction program over the next five years will be financed with State revenues. This represents a major increase over previous years.

Increased State funding is the result of legislation (House Bill 2306) enacted in 1985. This legislation increased fuel taxes by 3 cents per gallon, effective January 1, 1986, and reallocated a share of vehicle license taxes for highway construction. Furthermore, House Bill 2306 gave each county the option of having its voters approve a one-half cent increase in sales taxes, revenues from which would be earmarked for construction of county controlled-access roadways.

A one-half cent increase in sales taxes (Proposition 300) was approved by Maricopa County voters in October 1985. The sales tax increase became effective as of January 1, 1986, with proceeds going to highway construction.

Bond revenues represent an important vehicle for accelerated financing of highway construction in urban and rural areas of the State. Nearly $1 billion in bonds have or will be issued by ADOT between fiscal years 1987 and 1991, with $850 million funding controlled-access routes in Maricopa County and $16 million in Pima County. The balance of the bond proceeds will finance Statewide highway improvements.

These revenue sources not only cover the cost of land acquisition and roadway design and construction, they also fund ADOT's construction oversight costs. If ADOT can realize greater efficiencies in its oversight responsibilities, more funds would be made available for development of Arizona's highway system.

Expenditures for purchase of land and design and actual construction of new highways during fiscal year 1987-88 will total approximately $716 million. This contrasts with fiscal year 1985-86 and fiscal year 1986-87 expenditures of approximately $371 million and $578 million, respectively. Over the next five years expenditures will total approximately $2.93 billion (see Table 1). This sharp increase in highway program expenditures is largely due to the initiation of an ambitious program to expand Maricopa County's urban freeway system.

TABLE 1

ESTIMATED EXPENDITURES ON HIGHWAY CONSTRUCTION PROGRAM
(FISCAL YEARS 1986-87 THROUGH 1990-91) [a]

Fiscal Year	Total Estimated Expenditures [b]	Estimated Construction Expenditures [c]
1987-88	$ 716,312,000	$ 452,693,000
1988-89	704,940,000	511,620,000
1989-90	685,475,000	542,145,000
1990-91	522,570,000	392,780,000
1991-92	302,500,000	237,440,000
	$2,931,797,000	$2,136,678,000

(a) Funds released during any specific fiscal year will not necessarily be expended during the same fiscal year. For example, a one year project authorized at the end of a given fiscal year would not be completed until the following fiscal year.

(b) These cost figures include estimated land acquisition (right-of-way), highway design and roadway construction (including construction engineering) expenditures.

(c) The cost figures do not include local government projects overseen by ADOT which are estimated to total $25 million annually.

Source: Arizona Department of Transportation's Five-Year Transportation Facilities Construction Program Report (fiscal year 1987-88).

Audit Scope and Purpose

Our audit focused on the staffing levels required by the Arizona Department of Transportation's Highway Operations Group to effectively and efficiently manage the State's highway construction program. The report presents findings and recommendations in the following areas.

- ADOT's construction staffing levels.
- ADOT's Construction Engineering Manpower Management System (CEMMS).

In addition, we developed other pertinent information concerning contracting for construction oversight. (see pages 37 through 38)

Due to time constraints, we were unable to address all potential issues identified during our audit. The section Areas For Further Audit Work (see pages 39 through 40) describes these potential issues.

Our audit was conducted in accordance with generally accepted governmental auditing standards.

The Auditor General and staff express appreciation to the Director and staff of the Arizona Department of Transportation for their cooperation and assistance during the course of our audit.

FINDING I

ADOT HAS NOT ADEQUATELY CONTROLLED CONSTRUCTION STAFFING LEVELS RESULTING IN OVERSTAFFING THAT HAS COST THE STATE AN ESTIMATED $7.4 MILLION OVER THE LAST FOUR FISCAL YEARS

The Arizona Department of Transportation (ADOT) has not adequately controlled construction staffing levels. Our analysis of construction engineering costs and other Statewide data indicates that overstaffing has cost the state an estimated $7.4 million over the last four fiscal years. Field visits and ADOT's own reviews further indicate that ADOT has been overstaffed. Before increasing staff levels to meet short-term program increases, ADOT should first consider making greater use of the alternatives it has to match staffing levels and workload. To ensure that ADOT staffs its construction engineering program appropriately, the Legislature should annually set and monitor construction staff levels.

Methodology

We used three different quantitative methods to determine whether ADOT's construction engineering program was appropriately staffed. Using different analytical methods helped to validate results. The analytical methods used were based on ADOT construction engineering cost goals, ADOT's past productivity and ADOT miscellaneous time (non construction related hours charged by ADOT staff).

In addition to analyzing several types of quantitative data, we visited district, area and construction orgs in the four districts to discuss and observe staffing needs. We also reviewed ADOT reports that studied staffing needs. Both the field visits and the ADOT reports were used to determine whether results obtained through analyses of Statewide data were reasonable.

Analyses Show That ADOT Construction Function Is Overstaffed

Results of all quantitative analyses we conducted indicate ADOT's construction function has been overstaffed the last several years.[1] Analyses of construction engineering costs, productivity and non construction related time charged by staff all indicate that ADOT has had more construction staff than the work required. Overstaffing over the last four years has cost the State an estimated $7.4 million.

Construction Engineering costs analysis indicates overstaffing - Analysis of construction engineering (CE)[2] costs indicates overstaffing of 21 to 101 staff from fiscal years 1983-84 through 1986-87. This analysis used ADOT's own CE cost goals as criteria in determining appropriate staffing for these years. These goals, expressed as a percentage of total project costs, were considered reasonable because they fall in the mid-range of other states' CE costs.[3] Several other states reported lower CE goals and costs. Further, when compared to historically attained productivity (see productivity analysis on page 11), ADOT could meet the CE cost goals without working at peak productivity.

The analysis determined the amount of staff needed per year using ADOT's CE cost goals as criteria. To determine needed staff, the appropriate CE cost goal was applied to total payments to contractors for each year to determine the allowed oversight cost amount. This amount was then divided by the historical construction staff-related cost per labor hour for the appropriate year to determine the amount

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(1) ADOT maintains it has steadily reduced its number of construction staff since 1976. ADOT prepared a schedule showing the ratio of staff to construction dollars has also decreased. We did not include this schedule in our report because the staffing data shown in the schedule cannot be verified. Furthermore, ADOT's analysis would not affect results of our current analysis which shows overstaffing has occurred the past four years.

(2) CE costs are all project oversight (inspection, survey, laboratory and administration) related costs borne by ADOT from the time a project starts through completion. Historically, labor expenses have comprised from 75-90 percent of total CE cost. CE cost is expressed as a percentage of the cost of construction (what is paid to the contractor actually building the road). ADOT's construction staff-related CE cost goals vary depending upon the size of the project, and range from 6.3 to 19.8 percent. The larger the project, the lower the CE percentage should be and vice versa.

(3) Of the 46 states surveyed, 25 states responded to questions concerning CE costs.

of oversight hours needed. Oversight hours needed were then divided by an hours per labor year figure based on historical data to calculate the total staff needed for the year. Overstaffing amounts were then determined by subtracting staffing needs from actual staff size. Overstaffing, as determined by CE cost analysis, is shown in Table 2.

TABLE 2

EXCESS CONSTRUCTION STAFF AS DETERMINED BY AN ANALYSIS
OF CONSTRUCTION ENGINEERING (CE) COSTS
FOR FISCAL YEARS 1983-84 THROUGH THREE QUARTERS OF 1986-87

Fiscal Year	Contractor (a) Payments	x	CE (b) Goal	=	CE Cost Goal	÷	Cost Per (c) Hour	=	Hours Needed	÷	Hours Per (d) Year	=	Staff(e) Needed	vs.	Actual(e) Staff	Excess Staff
1983-84	$165,481,277.30	x	8.70%	=	$14,396,871.13	÷	$16.18	=	889,794	÷	1,789	=	497	vs.	544	-47
1984-85	202,097,225.12	x	8.14%	=	16,450,714.12	÷	17.21	=	955,881	÷	1,789	=	534	vs.	591	57
1985-86	184,652,465.89	x	8.54%	=	15,769,320.59	÷	17.17	=	918,422	÷	1,789	=	513	vs.	614	101
1986-87	179,807,627.33	x	7.85%	=	14,114,898.75	÷	18.63	=	757,643	÷	1,342	=	565	vs.	586	21

(a) Excludes projects administered by private consulting firms.
(b) Overall goal based on cumulative application of ADOT CE cost goals minus historical non construction org CE costs. On the average, 79 percent of all CE costs were charged from construction orgs.
(c) Based on ADOT's construction staff related costs and construction hours worked.
(d) Average number of construction engineering hours worked including overtime per year by one employee.
(e) Does not include staff needed to oversee consultant managed projects.

Low productivity also indicates overstaffing - Low productivity by ADOT construction staff over the last four fiscal years also indicates overstaffing. Our analysis indicated overstaffing ranging from 38 to 207 staff when ADOT was held to historically attainable productivity standards.

The productivity analysis, like the CE cost analysis, examined the efficiency with which staff oversee and process construction projects. The analysis compared how much construction work (payments to contractors in dollars) was processed per ADOT staff hour charged to construction oversight. A historically attainable productivity indicator ($163 per hour) was then selected as criterion for determining how many staff were needed per fiscal year if staff worked at that productivity level. To calculate ideal staff size, first, payments to contractors for the year (the amount of

work to be processed by ADOT staff) were divided by the productivity standard to determine total hours needed to process the work if working at the productivity standard. Then, the total hours needed were divided by 1,789 (historical average number of construction related hours charged by one employee for one year) to calculate needed staff. Needed staff were then subtracted from actual yearly staff totals to determine overstaffing. Overstaffing as shown by productivity analysis is shown in Table 3.

TABLE 3

EXCESS CONSTRUCTION STAFF AS DETERMINED BY AN ANALYSIS
OF CONSTRUCTION STAFF PRODUCTIVITY
FOR FISCAL YEARS 1983-84 THROUGH THREE QUARTERS OF 1986-87

Fiscal Year	Adjusted (a) Contractor Payments	÷	Productivity Standard	=	Hours Needed	÷	Average Yearly Staff Hours	=	Staff (b) Needed	vs.	Actual (b) Staff	=	Excess Staff
1983-84	$140,203,179.43	÷	$163.17	=	859,246	÷	1789	=	480	vs.	544	=	64
1984-85	149,831,650.41	÷	163.17	=	918,254	÷	1789	=	513	vs.	591	=	78
1985-86	118,949,030.21	÷	163.17	=	728,988	÷	1789	=	407	vs.	614	=	207
1986-87 (3 Quarters)	119,891,185.03	÷	163.17	=	734,762	÷	1342	=	548	vs.	586	=	38

Source: Auditor General Staff analysis of ADOT Construction Costs and Labor Data.

(a) Amounts adjusted for inflation using Arizona Construction Cost Index.
(b) Does not include staff needed to oversee consultant managed projects.

$163 per hour was selected as the productivity standard for several reasons. First, the standard has already been achieved by ADOT on a Statewide basis in fiscal year 1986-87. Second, the standard has been achieved or exceeded by all districts except District Two in at least two of the last four years. The standard represents from 77 to 92 percent of the peak productivity of all the districts except

District Two. Third, because District Two's productivity lowers the standard, the $163/hour figure is actually somewhat conservative.[1] District and Statewide productivity over the last four fiscal years is shown in Table 4.

TABLE 4

DISTRICT AND STATEWIDE PRODUCTIVITY
FISCAL YEARS 1983-84 THROUGH THREE QUARTERS OF 1986-87

Year	District 1	District 2	District 3	District 4[a]	Statewide[b]
1983-84	$170/hr.	$128/hr.	$153/hr.	$211/hr.	$159/hr.
1984-85	134	128	179	162	138
1985-86	102	108	135	199	118
1986-87 (Three Quarters)	178	104	171	196	163

(a) While District Four yearly productivity figures were on the average higher than other districts, it also had the widest variance in quarterly productivity rates. For example, in fiscal year 1985-86, District Four productivity varied from $80/hour to $241/hour. This variance is due to seasonal changes in District Four workload with lowest productivity occurring during winter months.

(b) Statewide figures differ from an average of the four districts because of varying workloads per district.

Source: Auditor General analysis of ADOT construction costs and labor data.

(1) According to current and former ADOT staff, District Two has been overstaffed in past years, partially because of an expected increase in construction activity due to a sales tax initiative that subsequently didn't pass. Because District Two has qualities similar to all of the other districts (either a large urban area, or rural and mountainous areas), we determined it was reasonable to hold District Two to similar productivity expectations.

Excessive miscellaneous time charged - Even a limited analysis using miscellaneous (non construction related) time charged by staff indicates that ADOT has had more construction staff than the work required.

Construction staff charge time to a "miscellaneous" code when performing non construction related tasks. Miscellaneous activities can occur because they are scheduled such as training sessions, or because of lack of construction work because of funding, weather, contractor problems or project scheduling changes. Auditor General Staff field visits to construction orgs found that construction staff perform a variety of tasks on miscellaneous time. These include, for example, road maintenance, building maintenance and painting. One org constructed a loading dock and put skirting around a trailer.

Unlike CE and productivity analyses, miscellaneous time analysis does not examine efficiency. The analysis only identifies excessive miscellaneous hours charged, and does not identify whether excessive staff are assigned to construction jobs, or whether they work at an adequate pace. [1] Our analysis revealed that ADOT's excessive miscellaneous time over the past four fiscal years translated into overstaffing ranging from 17 to 32 staff, except for fiscal year 1984-85 when ADOT staff did not use all of the miscellaneous time allowed. Our analysis simply calculated the excessive amounts of miscellaneous time (amounts over the ADOT allowed 10 percent of total time) using ADOT labor data, and converted that to excess staff by dividing total excess hours by the average number of hours worked per year per employee. Excess staff as determined by an analysis of miscellaneous time is shown in Table 5 (see page 15).

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(1) ADOT analyses discussed on Page 17 suggest that at times ADOT has not worked efficiently. Excessive time has been charged on some occasions, however, the extent of this problem is unknown.

Miscellaneous time was excessive in several construction orgs analyzed. ADOT management stated that miscellaneous time should not exceed 10 percent of total time charged by staff. Our analysis, however, found some orgs with more than 60 percent miscellaneous time for some months. From January 1985 through March 1987, 10 of the 32 construction orgs averaged from 20 to 36 percent miscellaneous time.

TABLE 5

EXCESS CONSTRUCTION STAFF AS DETERMINED BY AN ANALYSIS
OF MISCELLANEOUS TIME CHARGED
FOR FISCAL YEARS 1983-84 THROUGH THREE QUARTERS OF 1986-87

Fiscal Year	Total Hours Charged	X	10% Miscellaneous Allowance	=	Allowed Misc. Time	vs.	Actual Misc. Time	=	Difference	÷	Average Yearly Staff Hours	=	Excess Staff
1983-84	1,087,309	X	.10	=	108,731	vs.	166,058	=	57,327	÷	1789	=	32
1984-85							(a)						
1985-86	1,256,224	X	.10	=	125,662	vs.	177,010	=	51,388	÷	1789	=	29
1986-87 (Three Quarters)	889,526	X	.10	=	88,953	vs.	111,866	=	22,913	÷	1342	=	17

Source: Auditor General Staff analysis of ADOT Construction Costs and Labor Data.

(a) Statewide, ADOT staff accrued less than the 10 percent allowable miscellaneous time; therefore, the analysis was not applicable.

Overstaffing has cost the State $7.4 million - Overstaffing over the last four fiscal years has cost the State approximately $7.4 million. The cost of overstaffing was determined by multiplying the number of excess staff (as determined by the CE cost analysis) by the average cost per employee per year. We selected the CE cost analysis as our primary indicator of overstaffing because it was generally more conservative than the productivity analysis. We felt this gave ADOT the "benefit of the doubt" on differences between the analyses. Costs of construction overstaffing over the last four fiscal years are shown in Table 6.

TABLE 6

COST OF CONSTRUCTION OVERSTAFFING:
FISCAL YEARS 1983-84 THROUGH 1986-87

FISCAL YEAR	EXCESS STAFF [a]	AVERAGE STAFF WAGE COST [b]	OVERSTAFFING COST
1983-84	47	$31,115	$ 1,462,405
1984-85	57	33,129	1,888,353
1985-86	101	33,045	3,337,545
1986-87	21	35,941	754,761
TOTAL			$ 7,443,064

(a) Based on Construction Engineering Cost Analysis.
(b) Based on historical construction-related costs including equipment and travel costs incurred while working on construction projects, plus a 10% miscellaneous time cost allowance.

Source: Auditor General Staff analysis of ADOT construction costs and labor data.

Field Visits And ADOT Analyses Also Indicate Overstaffing

Field visits and ADOT analyses support the conclusion that ADOT has overstaffed its construction function. Field visits to the engineering districts provided several examples of overstaffing and under utilization. In addition, ADOT field reviews have demonstrated overstaffing.

Overstaffing seen during field visits - Field visits by Auditor General staff to the four engineering districts provided examples of overstaffing and staff under utilization in at least two districts. We visited most construction orgs in the State, and spoke with district and area management and staff. The following examples illustrate staffing inefficiencies.

- The District Two engineer acknowledged that his district is currently overstaffed by 50 to 60 full-time equivalent employees (FTEs). The district expects to have an average surplus staff for the next 12 months, of approximately 44 FTEs. Additionally, the engineer indicated that he would not become concerned about district staff size until it was reduced to 100 FTEs (current staff size is approximately 140 FTEs). According to other current and former ADOT staff, this district has been overstaffed in past years. The district had expected increased construction that did not occur.

- District Four maintains a nearly full construction work force (averaging approximately 70 staff) throughout the winter, even though construction work is primarily conducted from May through October due to climatic conditions in this district. Although some construction related tasks are performed, most staff are involved in non construction duties such as maintenance, snowplowing assistance, paperwork and training. One org resident engineer said that his staff ran out of things to do this past winter.

- District Four did not appear to be utilizing temporary staff and summer interns efficiently. The district normally hires approximately 30 temporary staff and summer interns each spring to help the large amount of work that is done during the peak construction season. However, our visits to the two orgs that have the temporary staff indicated that there was no construction related work for them and that there would not be much for a few more months. To keep the temporaries busy, some were assigned to "double-up" with regular ADOT staff. Org staff have indicated that by the time the "crunch" occurs, the temporaries and interns are not available because they have returned to school.

- One resident engineer in District Four stated that he had surplus staff for most of the year. Currently, his org is staffed with approximately 20 permanent employees year-round and approximately ten temporary staff during the summer. However, because workload is seasonal, staffing requirements vary. He stated that the org needed six workers for three months, 12 workers for six months, and 30 workers for three months. As a result, the org is essentially overstaffed for three-quarters of the year.

ADOT analyses also show overstaffing - ADOT field reviews also demonstrate overstaffing. ADOT Field Review Services conducts reviews of orgs or projects, reporting on several construction-related items, including staff utilization. Overstaffing found in field reviews are shown in the following examples.

- A recent ADOT review revealed surplus staff in two orgs in District Four. One org, with an average staff size of 19, had a surplus of 12 staff (approximately 63 percent surplus). The other org, with an average staff size of 28, had a surplus of ten staff (approximately 36 percent surplus). ADOT figures calculate the excess labor cost for those two orgs for the two months examined at more than $102,000. Auditor General field visits to the same two orgs found similar staff under utilization.

- A 1984 ADOT field review found excessive survey hours charged by ADOT crews on a particular project in District Two. A comparison of estimated time needed to perform the work vs. actual hours charged showed that an excess of 6,000 hours was charged. Those excess hours translate into nearly five surplus staff to perform survey activities for the duration of the project (280 working days). In addition, according to central office staff, another org in the district had excess survey staff and transferred them to the org assigned to this project.

- Another 1984 field review of two projects in District One revealed excessive amounts of time charged by ADOT survey crews for two work activities. One construction activity overran ADOT estimates by 241 percent. The other activity had an overrun of 315 percent. Central office also questioned the use of two survey crews, when only one was actually needed, because the two projects were adjacently located. The excessive hours charged to survey (in contrast to planning estimates) could possibly be related to the extra survey crew assigned to the project. The number of staff assigned to office duties was also questioned. There were four employees in the office, when actually only one was needed. Furthermore, the number of supervisory and lab staff on another project were considered to be excessive.

- ADOT recently reviewed a project in District Three and found a significant overrun of hours charged to the preliminary phase of the project. Based on ADOT estimates, ADOT crews overran hours needed for this phase of the job by 251 percent. According to Central Office staff, the overrun can be attributed to transfers of staff from other districts. In addition, further analysis by Auditor General staff indicated that hours charged by District Three staff were approximately the number of hours needed to perform the function. Therefore, excessive hours charged by staff from the other districts may have contributed to the significant overrun.

Alternatives Should Be Considered Before Increasing Staff Levels

Before adding construction staff to meet short-term increases in workload, ADOT should first consider using alternative methods for providing construction oversight. Staff needs will flutuate both over and under current levels over the next five years. ADOT may not have to increase staff to meet short-term program increases if ADOT increases its use of consultant engineers and exercises other options for adjusting workload for two out of the next five years.

Staff needs will fluctuate over the next five years - As shown in Table 7, page 20, ADOT's construction staffing needs will fluctuate over the next five years. Based on an analysis using CE cost goals,[1] ADOT's staff needs will increase significantly for two of the next five years. However, at current levels ADOT will be overstaffed in two of the other three years.

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(1) The CE cost analysis is the same as the method described on page 10, except future construction estimates from ADOT's five year statewide and local government plans were used. Again, this represents a more conservative estimate than the estimates based on ADOT's historically attained productivity.

TABLE 7

ESTIMATED CONSTRUCTION STAFFING NEEDS
FISCAL YEARS 1988 THROUGH 1992

FISCAL YEAR	CURRENT STAFF [a]	PROJECTED STAFF NEEDS [b]	DIFFERENCE (current minus projected)
1987-88	600	517	83
1988-89	600	605	(5)
1989-90	600	660	(60)
1990-91	600	645	(45)
1991-92	600	509	91

(a) For 1986-87, ADOT's construction work force averaged 600 FTEs, and is expected to remain at or above that level.

(b) Future staff projections were based on the following assumptions. First, ADOT would continue to contract out approximately 25 percent of its construction function to private firms or local governments (in fiscal year 1986-87, ADOT contracted out 25 percent to private firms and local governments). Second, ADOT's construction-related CE cost goal would be 7.85 percent (the same as in 1986-87), and ADOT would be able to meet that goal. Further, construction costs were assumed to increase by 5 percent. We projected construction workload based on the five year statewide and local government construction plans estimates according to a formula provided to us by ADOT Administrative Services Division.

Source: Auditor General analysis of ADOT five year construction plans.

ADOT could manage workload fluctuation more efficiently - ADOT could manage its workload more efficiently if it made better use of alternatives to increased staffing levels. Our analyses indicate that ADOT has historically maintained a high base staffing level although workload fluctuates in seasonal and multi-year cycles. As shown in Figure 3 (see page 22), staffing has remained relatively stable while workload has experienced both highs and lows. Although costly and inefficient, maintaining a high permanent staffing base has enabled ADOT to meet much of its peak workload Statewide with existing staff. ADOT has made some use of alternative approaches to managing peak workloads. However, it could operate more efficiently if these approaches were used more widely and effectively. These alternative approaches include:

- **Use of consultant engineers** - Currently, ADOT contracts approximately 25 percent of its total work to consultant engineers, who perform construction engineering functions normally done by ADOT staff. ADOT has used consultants on technically complex projects, such as the I-10/I-17 interchange (the stack), and on projects ADOT did not want to oversee for other reasons. A primary benefit of using private consultants, however, is that ADOT only has to pay for this service when it is needed, thus reducing non productive time. ADOT could make greater use of consultants to manage fluctuations in workload. Consultants could be used, for example in District Two which expects a temporary increase in its workload over the next few years.

- **Contract out functions** - ADOT could increase its contracting out of specific construction engineering functions. Consultant engineers subcontract for survey crews and laboratory testing functions as needed, thus reducing non productive time. ADOT could adopt the same approach. According to a survey of other states, many states contract for surveying, lab and inspection functions.[1] According to the State of Colorado, having contractors perform staking lowered overall CE costs from 11 to 9 percent.

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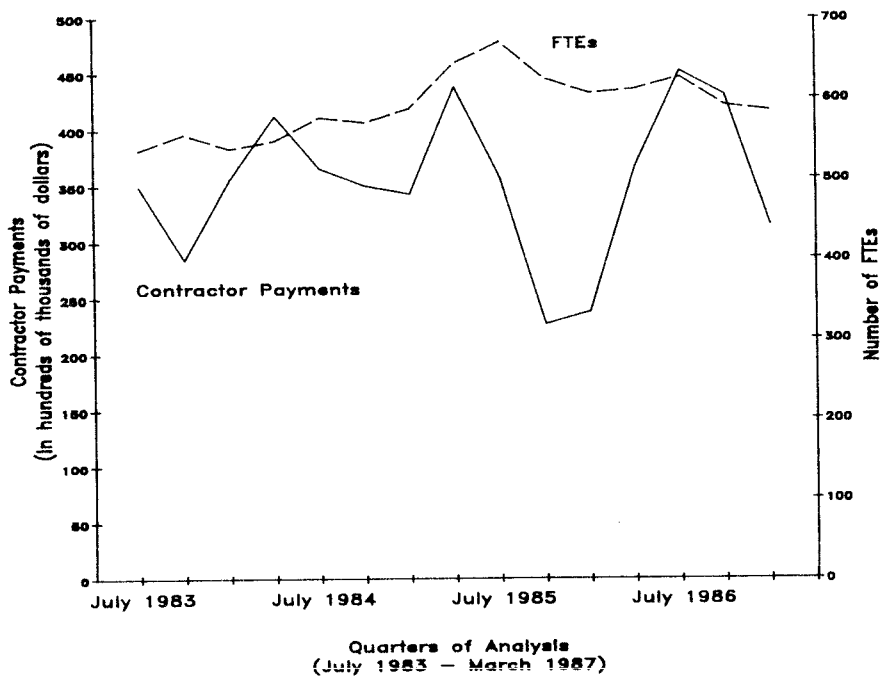
(1) Auditor General staff compiled a survey regarding state highway construction and distributed it to each transportation department across the country. Of the 50 surveys mailed, 46 states responded.

FIGURE 3

RELATIONSHIP OF STAFFING LEVELS TO WORKLOAD: [a]
FISCAL YEARS 1983-84 THROUGH THREE QUARTERS
OF 1986-87



(a) Construction projects monitored by engineering consultants have been excluded from this analysis.

Source: Auditor General Staff analysis of ADOT Construction Staff and contractor payments from July 1983 to March 1987.

- **Use of temporary staff** - ADOT could also increase and make more timely use of temporary staff to assist in meeting workload peaks. For example, ADOT currently uses some temporary staff in District Four, although these staff have not always been available when needed due to project scheduling delays (see page 17).[1] Colorado makes extensive use of temporary staff to meet its summer workload demands. Forty-one of the states we surveyed indicated they use temporary employees to meet workload peaks.

- **District transfers** - ADOT could also make more extensive use of transfers between districts to accommodate fluctuations in workload. As discussed previously, staff in seasonal districts accumulate excessive amounts of non productive time during the winter months. Transferring these staff or others in districts experiencing reductions in workload would help ensure that staff resources are used efficiently. For example, District II, from which staff have been transferred in the past, will still be overstaffed in fiscal year 1987-88 by an average of 44 positions. Thirty-seven states responding to our survey indicated they transfer staff among districts to handle workload shortages.

- **Share resources with maintenance** - ADOT may be able to utilize maintenance staff to assist during peak workload periods. Twenty states surveyed indicated that their construction and maintenance work forces occasionally share labor resources. Currently, ADOT construction staff assist maintenance crews during periods of low construction activity, however, maintenance, which has approximately 780 staff statewide, does not assist in construction during peak construction work periods.

Construction staff increases may be unnecessary - Before increasing staff size, ADOT should first consider more extensive use of the above alternatives as a means of handling workload fluctuations. We determined the portion of its program ADOT would have to contract out over the next five years if it maintained its current staffing level of 600. As shown in Table 8 (see page 24), a significant increase over the current level of 25 percent usage would be required for only two of the five fiscal years. The highest increase would be in fiscal year 1989-90 when consultant usage would total 33 percent. In two of the future fiscal years, consultant usage would actually decline over current levels.

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(1) Analysis of District Four staff size revealed that the permanent construction work force average 70 FTEs for the past two fiscal years, yet ADOT central office indicated the District only needs a year-round staff of 45. This has resulted in considerable non productive time during low construction periods. From November 1986 through April 1987, average miscellaneous time ranged from 15 to almost 50 percent. One org charged over 70 percent of its time to the miscellaneous code for two consecutive months.

TABLE 8

PERCENTAGE OF CONTRACTING FOR CONSTRUCTION ENGINEERING
NEEDED WITH CURRENT 600 FTE STAFF LEVEL
FOR FISCAL YEARS 1987-88 THROUGH 1991-92

FISCAL YEAR	CURRENT CE PERCENTAGE	PERCENTAGE OF CONTRACTED[a] CE NEEDED WITH 600 FTE	DIFFERENCE OVER/ UNDER CURRENT LEVEL
1987-88	25	12	(13)
1988-89	25	26	1
1989-90	25	33	8
1990-91	25	31	6
1991-92	25	10	(15)

(a) ADOT for FY 1986-87 contracted out 25% of its total workload. ADOT expects to contract out a similar amount in FY 1987-88.

Source: Auditor General analysis of ADOT construction costs and labor data.

The Legislature Should Control Construction Staff Levels

To increase control over staffing, the Legislature should set construction staff levels. ADOT has failed to adequately adjust its staff levels in the past, even though it developed an automated system to determine appropriate staffing. As is done in many other states, the Legislature, through its appropriations process, could set and monitor staffing levels.

Construction staff not adjusted based on workload - Our analysis revealed that ADOT construction staff levels have not been adjusted based on workload. During low periods in highway construction, ADOT has not decreased its staff levels.

ADOT implemented a manpower management system to assist in adjusting construction staffing to meet workload fluctuations. ADOT's Construction Engineering Manpower Management System (CEMMS), however, has not been fully utilized to assist in adjusting staff levels. ADOT management has not fully implemented the system nor required full utilization by field staff (see Finding II, page 27).

Increased legislative involvement - Because ADOT has not adequately controlled its staffing, the Legislature should consider setting and monitoring construction staff levels. Currently, ADOT determines its construction staffing needs based on its highway construction program. Neither the Legislature nor the Executive Budget Office (EBO) conducts a comprehensive review or regulates construction staff levels. According to an ADOT official, it would not be feasible to legislate construction staff levels, because workload cannot be accurately estimated.

However, results of a survey revealed that several other states do have their construction staffing positions determined by either a legislative review committee or an executive budget agency. Of the 46 states that responded to the survey, 18 indicated that a legislative review committee is involved in determining highway construction staff positions. In addition, 13 states indicated that an executive budget agency is directly involved in this function. Therefore, based on methods utilized by other states to determine staffing levels, it may be feasible for the Arizona Legislature to consider setting and monitoring construction staff.

The Legislature could set staffing levels based on construction information provided by ADOT. Several types of information could be used for monitoring and appropriations decisions. These include reports of CE costs, construction staff productivity, construction staff charges to miscellaneous time, future construction workload (estimates of future contractor payments), and the percentage of projects that ADOT expects to contract out. ADOT currently generates some of these reports from the CEMMS system and could generate others, as was done by Auditor General staff. Monitoring these reports on a regular basis would allow the Legislature to determine if ADOT is utilizing its staff effectively. Based on this information, the Legislature could then appropriate staff levels accordingly.

RECOMMENDATIONS

1. ADOT should first consider increasing its use of alternative staffing methods as needed to handle peak construction periods Statewide and in seasonal districts before adding additional permanent staff.

2. The Legislature should consider setting and monitoring ADOT construction staff levels.

3. The Legislature should consider requiring a follow-up performance audit in two years of ADOT's construction management function to review its progress in managing staff size.

FINDING II

ADOT'S CONSTRUCTION ENGINEERING MANPOWER MANAGEMENT SYSTEM IS NOT BEING UTILIZED EFFECTIVELY AND NEEDS GREATER MANAGEMENT SUPPORT

Although the Arizona Department of Transportation (ADOT) has committed at least $550,000 to its Construction Engineering Manpower Management System (CEMMS) since 1982, the system is not being utilized effectively and lacks adequate support. CEMMS is not being used to effectively manage ADOT's construction engineering (CE) resources. ADOT needs to more fully support the system and to address system deficiencies if CEMMS is to become a viable management tool.

BACKGROUND

CEMMS was developed to assist ADOT in controlling its construction engineering resources. In the early 1980s, ADOT recognized the need for better methods of projecting manpower needs and improved management of construction engineering resources. In addition, although ADOT has approximately 600 construction engineering employees, this work force is not appropriated by the Legislature. Instead, ADOT determines work force size to fit its construction work program. As a result of ADOT's need for improved management of its CE resources and Legislative concern over effective control of ADOT's work force, the Department developed a construction management system.

CEMMS was designed to provide construction managers with tools to plan, schedule and control construction engineering personnel and costs. The primary objective of the design and implementation of CEMMS was to develop a system that would:

- Reduce construction engineering costs.
- Improve work and budgeting methods.
- Provide end products to determine the most effective use of ADOT construction engineering personnel and equipment.

Development of CEMMS began in December 1981, and the system was implemented Statewide on October 1, 1982. Since CEMMS was implemented, ADOT has

committed at least $550,000 to the system, of which an estimated $460,000 has been incurred by central office staff, with an additional $93,000 paid to consultants. [1]

CEMMS Is Not Effectively Used To Manage CE Resources

CEMMS is not being utilized effectively to manage ADOT's CE resources. ADOT has not effectively used CEMMS functions to plan and staff, budget, schedule, and monitor these resources.

Planning and staffing functions not utilized effectively - CEMMS is designed for short-term and long-term planning. Short-term planning is needed to determine the number of employees required and which months they are needed, so plans may be made to meet those needs. Long-term planning allows management to take action to prevent significant staffing shortages or surpluses. [2]

However, the CEMMS planning and staffing functions are not being utilized effectively to plan ADOT's labor requirements. ADOT Highway Operations management indicated that CEMMS was only slightly effective in assisting them to forecast and control labor needs. District engineers stated that "CEMMS as a manpower projection tool has been nearly useless." As a result, manual staffing projections are made by the District engineers. Additionally, a majority of resident engineers surveyed said that they do not use CEMMS staffing guidelines in preparing project staffing plans and primary work schedules. Instead, some indicated that they staff based on their own experience and judgment, as well as available personnel. Recent CEMMS field reviews also show that project staffing plans are not submitted for all projects and that staffing plans are rarely updated.

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(1) These figures represent only CEMMS costs incurred by central office staff and by ADOT for consultants used to implement, review and modify the system. Although district personnel are also involved in the operation of CEMMS, their CEMMS related expenses are not included. District and area operations technicians, as well as resident engineers, spend part of their time on CEMMS related activities.

(2) According to the CEMMS manual, a long-range plan is developed once a year and covers a two-year period. The short-range plan is updated monthly and projects staffing needs for the next 12 months.

Budget module also not utilized - Although the CEMMS budget module allows for cost planning, it is not completely understood or fully used by District personnel. The CEMMS budget module is designed to allow managers to plan costs and monitor project costs. A budget is developed to plan for costs of construction engineering, and is based on the work to be done.

Interviews with district management, however, revealed that they were not aware of, or did not use, the CEMMS budget module. Furthermore, discussions with district personnel revealed that CE cost estimates, which appear on project staffing plans, do not always reflect actual expected costs, but instead may result from numbers backed into the plans to show expressed or implied CE cost limitations.[1] We found that a perceived CE cost limit of 10 percent, for example, caused district personnel to calculate 10 percent of the project cost and develop a staffing plan based on that calculation. However, according to ADOT staff, actual staffing needs may vary significantly from the "10 percent plan."

CEMMS scheduling function misused and ineffective - ADOT has underutilized and misused the CEMMS scheduling function. CEMMS provides for short-term (weekly) scheduling to assess short-term labor needs, to plan personnel assignments for efficient use of available staff, and to communicate assignments to employees. A good plan or schedule has both primary and secondary or alternate work schedules. However, according to the CEMMS manual, when schedules are not written and engineers rely on oral communications, crews are not usually deployed effectively.

A survey of construction orgs indicated that more than 25 percent of the orgs do not prepare primary work schedules weekly. More than 95 percent of the orgs indicated that they do not post primary work schedules. Primary work schedules are used to ensure that needed staff are assigned to construction projects.

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(1) Additionally, once a construction project is underway, project charges are sometimes miscoded in order to keep CE costs within expressed or implied limitations, particularly on small dollar jobs where ADOT's costs, in relation to total costs, are higher. District engineers and central office staff have indicated that miscoding of project charges is occurring, due for the most part to "expressed and/or informal direction" to stay within the 15 percent CE cost limitation on each project.

In addition, some resident engineers do not always accurately reflect their labor needs on the primary schedules. For example, an ADOT report pointed out that many schedules are submitted showing 90 percent staff scheduled for project-related work, yet labor cost distribution reports later show as little as 55 percent of the actual labor costs charged to project related work.

Furthermore, our survey of construction orgs revealed that more than half of the orgs do not have formal secondary work schedules. More than 77 percent of the orgs indicated that secondary work assignments were not posted for employees. Secondary assignments cover productive work of lower priority when the primary assignments are interrupted by, for example, winter shutdowns, rain or changes in a contractor's schedule.

Monitoring module underutilized and ineffective - The CEMMS monitoring module is also underutilized and ineffective. CEMMS currently generates 16 planning and monitoring reports. The goal in monitoring is to identify significant problems; for example, to allow resident engineers to identify projects in which man hours or CE costs excessively overrun initial projections.

However, a survey conducted by our Office found that nearly half of the construction orgs do not regularly receive CEMMS reports. One area engineer indicated that he had not received any reports in nearly a year. ADOT district engineers reported that some districts have decided to stop distribution of CEMMS reports to resident engineers, which eliminates feedback on labor usage and CE costs. Interviews with district personnel also revealed that little to no formal action is taken once problem projects are identified.

The System Is Not Fully Supported

ADOT needs to more fully support CEMMS. Deficiencies and potential improvements of CEMMS have been pointed out to ADOT management since System implementation, but little action has been taken.

Problems identified - Deficiencies of and potential improvements to CEMMS have been pointed out to ADOT management repeatedly since 1982, through consultant reports and internal memorandums. Many issues, such as lack of management direction, inadequate district staff commitment, system analysis and updating, and training have been cited on several occasions.

- December 1982 - CEMMS Final Report presented to the ADOT State Engineer by Roy Jorgensen Associates, Inc., Engineering and Management Consultants. Jorgensen defined action needed during implementation to bring CEMMS to full effectiveness. The report also pointed out:

  - Need for more involvement of the district engineers.
  - Lack of intended district staff commitment to CEMMS.

- November 1983 - CEMMS Progress Report memorandum from the Construction Engineer to the State Engineer, Chief Deputy State Engineer and Deputy State Engineer, Highways Operations Group. The memo summarized CEMMS problems and progress-to-date, and made several recommendations for management consideration. Points discussed included:

  - Need for more involvement of the district engineers.
  - Lack of intended district staff commitment to CEMMS.
  - Need for clarification of management's desires for central office CEMMS involvement.
  - Need for more central office staff.
  - A recommendation for a follow-up review of CEMMS by consultant.
  - Need for training.
  - Need for more interaction with ADOT's Information Systems Group (ISG).
  - Problems with project scheduling.

- September 1984 - CEMMS Status Report memorandum from the Construction Engineer to the State Engineer. The memorandum:

  - Expressed concern over the effective use of CEMMS as a management tool by headquarters and district personnel.
  - Recommended a follow-up review of CEMMS by a consultant.

- January 1985 - CEMMS Review Report prepared by Roy Jorgensen Associates, Inc., Engineering and Management Consultants. Reviewed CEMMS system design, data processing and implementation; and made 12 recommendations based on their findings. Recommendations included:

  - Clarification of CEMMS responsibilities.
  - Emphasis on more involvement of central office in management analyses and setting Statewide manpower levels.
  - Central office CEMMS field reviews.
  - More analysis at the district level.
  - Updates of planning values [1] and system software.

- November 1985 - Suggestions for Improving the ADOT CEMMS COPES Application submitted by Robert J. Demster, Jr., of Project Management Systems Consulting, to the CEMMS supervisor. The memo discussed seven major areas the consultant identified as CEMMS needs. Among them were:

  - Need for training.
  - Need to study and update certain CEMMS elements.
  - Need for more CEMMS central office staff.
  - Need for analysis of field staff information requirements.

- January 1986 - CEMMS Progress Report memorandum requirements from the CEMMS Supervisor to the Manager of Field Review Services. The memo cited deficiencies in several areas that have made CEMMS inefficient, inaccurate, and of questionable utility for project monitoring and labor forecasting. Deficiencies were noted in:

  - Training.
  - Lack of Central Office CEMMS field reviews.
  - Analysis and updating of planning values and other system components.
  - The number of Central Office CEMMS staff available to perform the required functions.

- March 1987 - District Recommendations for CEMMS Program presented by ADOT district engineers to the Deputy State Engineer, Operations Section. The memo listed the concerns and recommendations district engineers had of the CEMMS program in five major areas: reliability of reports, coding errors, schedule reliability, labor projections, and management support. Specific problems were listed, including:

  - Lack of overall direction of the CEMMS program.
  - Inadequate central office CEMMS involvement.
  - Lack of adequate central office CEMMS staff.
  - Need for more interaction with and support from ISG.
  - Problems associated with project scheduling.
  - Lack of training.

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(1) Planning values are used for guidance in determining construction engineering labor requirements. The planning values are expressed in terms of labor hours per planning unit. For example, a planning value of 96 means that it requires 96 labor-hours to perform a particular activity.

- March 1987 through May 1987 - CEMMS memos from the Assistant State Engineer, Construction Section, to the Deputy State Engineer, Highway Operations Group. Three memos were written that discussed current CEMMS deficiencies, and listed items that had been accomplished, were scheduled or needed to be addressed to update, improve and utilize the system as originally intended. Included were:

  - Plans for training and field reviews.
  - Need for strong commitment to the CEMMS program at all levels.
  - Need for greater staff commitment by operations technicians.
  - Possible need for more CEMMS Central Office staff.
  - Need for system updating.
  - Need for more interaction with and support from ISG.
  - Need for evaluation of System software.

Little action taken - Although ADOT management is aware of CEMMS deficiencies and potential improvements, little action has been taken. CEMMS updating has been recommended since January 1985, but no system updating has been accomplished since the start of the CEMMS program. ADOT only recently began follow-up field reviews. Pending requests for additional central office staff are being deferred until proper evaluation of CEMMS is made and the system is fully operational. Problems with inadequate district staff commitment still exist. Furthermore, strong commitment and need for management determination of staff duties and responsibilities and overall program direction still need to be addressed.

ADOT Needs To Take Action To Make CEMMS Viable

ADOT needs to address System deficiencies if CEMMS is to become a viable management tool. Important system elements need to be maintained, and management issues should be addressed if CEMMS is to become effective.

System elements - Important system elements need to be maintained. Consultant reports and internal ADOT memos point out that CEMMS should be periodically updated. The CEMMS manual contains guidelines for reviewing and updating the system annually to ensure that it is kept current and in tune with ADOT's work methods. However, critical system elements have not been updated. For example, planning values were initially determined in 1982 from estimates of ADOT senior resident engineers. ADOT expected to update the planning values based on actual information once the program was underway, but this has still not been done. Five

year-old estimates continue to be used. Failure to update planning values is one reason cited by district engineers for CEMMS ineffectiveness in projecting manpower.

Management issues - Management issues should also be addressed if CEMMS is to become an effective manpower management tool. Central office's role in Statewide construction staff management should be restored. Additionally, management should address issues dealing with inadequate staffing and inadequate support from ADOT's Information Systems Group.

Central office's role in Statewide labor management should be reasserted. Roy Jorgensen Associates said that an important part of CEMMS implementation is involvement of the central office staff in overall Statewide staffing. When CEMMS was implemented it was used by central office to balance classifications and staffing for the State. District engineers, however, strongly objected to having central office make these decisions for them. In January 1985, Jorgensen found that central office had discontinued that practice. Control of CEMMS was turned over to the districts. Highway Operations management indicates that central office's role is to assist the districts in managing their labor resources. As a result, there is little Statewide management of CE staff. Moreover, central office feels that the districts are responsible for managing their CE labor and, therefore, see little need to monitor or take action when problems arise.

Additionally, management should address inadequate central office staffing for CEMMS. Although central office has added staff in the last year, there are still some questions as to their capacity to perform major CEMMS functions. In 1986, the CEMMS supervisor requested six additional positions to adequately staff three major functions: CEMMS training and technical support, data processing, and audits and analysis. Management also needs to reduce the amount of non-CEMMS time to which it assigns CEMMS staff. District engineers cited reassignment of CEMMS central office staff by senior management to tasks unrelated to CEMMS as one reason CEMMS staff have been unable to perform some of their functions. They reported that 20 to 50 percent of CEMMS central office staff time has been spent on duties not envisioned at the inception of the program.

Finally, ADOT upper management needs to address the lack of adequate Information Systems Group (ISG) involvement and support for CEMMS. When CEMMS was being designed, ADOT's Information Systems Group declined to assist in the effort because the software CEMMS uses is a vendor purchased system. The system's continued function and maintenance was to be worked out between the vendor and CEMMS central office staff. However, ADOT has had to hire a consultant on several occasions to modify system software. According to CEMMS staff, lack of ISG support needs to be addressed by ADOT management. ADOT's ISG is part of the Administrative Services Division, while CEMMS is located in the Highways Division. Highways Division management has indicated that they will seek firm commitments from ISG for support of the CEMMS System.

RECOMMENDATIONS

1. ADOT should strongly support the CEMMS program, requiring full utilization by both central office and district management.

2. ADOT should provide adequate resources to properly carry out the CEMMS program at the central office, district and area levels.

3. The ADOT director should require that sufficient support be given CEMMS by the ADOT Information Systems Group.

4. ADOT should:

   - Address current CEMMS deficiencies and direct that adequate analysis and modification of the System be accomplished.

   - Clearly define the CEMMS program goals and objectives.

   - Specify the responsibilities of each organizational level, from senior management to field staff.

- Reassert central office management's role in setting Statewide labor levels.

- Make provisions for more management analysis at both the central office and district levels.

OTHER PERTINENT INFORMATION

During the audit other pertinent information was developed regarding the cost of consultant managed construction projects.

Consultant Managed Construction Projects

Consultant managed (CM) CE costs have varied when compared to ADOT CE costs for similar-sized projects. On large projects, CM costs have been lower. However, on small and medium-sized projects CM costs have been higher. ADOT, however, could realize certain benefits that may offset any extra costs if the Department appropriately employes engineering consultants.

ADOT contracts with engineering consulting firms to perform construction engineering functions on a limited number of projects. Reasons for entering into these contracts are twofold: 1) for ADOT to meet peak workload demands, and 2) to assist ADOT when the Department does not have the technical expertise to manage certain specialized projects. The department has entered into at least 30 contracts of this nature during the last three years.

Since the number of consultant managed projects is small, CE cost comparisons with ADOT managed projects must be considered tentative. [1] (See Table 9) Among the two largest categories of construction projects the CE cost percentages of consultant managed projects are lower than ADOT managed projects. Within the four remaining project size categories for which cost comparisons can be made, however, CE cost percentages are higher for consultant managed projects. At times, these differences are considerable.

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(1) Cost comparison is also difficult because consultants may charge costs which ADOT cannot. On Federal participation highway projects, a consultant can charge a pro-rated portion of the firm's overhead costs to construction engineering. ADOT is not permitted to do this on projects managed in-house although the Department incurs similar overhead costs.

ADOT could realize certain benefits that may offset any extra costs on medium and smaller projects if the Department appropriately utilizes engineering consultants. Instead of hiring additional construction staff during workload peaks, consultants could be employed as needed. In such instances, ADOT only has to contract for additional construction staff when needed and would not be required to release or transfer employees when the workload returns to normal.

TABLE 9

CONSTRUCTION ENGINEERING COST PERCENTAGE COMPARISONS
OF COMPLETED CONSULTANT AND ADOT MANAGED CONSTRUCTION PROJECTS
FISCAL YEARS 1983-84 THROUGH 1986-87

Project Size	CE Percentage Consultants	Number	CE Percentage In-House	Number
$10 Million +	7.04%	2	8.70%	2
$5-9.99 Million	6.51	1	9.38	13
$2-4.99 Million	15.99	5	10.11	24
$1-1.99 Million	17.15	4	11.77	55
$500,000-999,999	17.80	4	11.37	54
$100,000-499,999	28.72	5	16.36	132

Source: Auditor General analysis of ADOT construction costs

AREAS FOR FURTHER AUDIT WORK

During the course of our audit we identified potential issues that we were unable to pursue because they were beyond the scope of our audit or we lacked sufficient time.

- **Could the claims documentation process be improved?**

  Several ADOT employees expressed concern that contractor claims for highway construction may be excessive. A December 1986 report indicated that the total potential liability to ADOT for outstanding claims was approximately $24 million. Of the $24 million, ADOT paid out $10 million (42 percent of the total liability). In addition, a January 1987 report revealed that ADOT has approximately $14 million in active contractor claims.

  Further audit work is needed to determine why the amount of claims is so high and what can be done to address the problem.

- **Should ADOT's design process be improved?**

  Numerous Highways Division staff and one contractor have indicated that construction design plans are inadequate or of poor quality, and lead to many problems in the field. One ADOT official attributed poor plans to ADOT's current accelerated project schedule. Others indicated that there is inadequate coordination of design plans on projects that have multiple design consultants. Additionally, ADOT staff stated that poor design plans can result or have resulted in an excessive number of contract change orders, force accounts and claims.

  Further audit work is needed to verify staff complaints about the design process and to determine what can be done to minimize design problems in the future.

- **Could ADOT streamline its organizational structure and eliminate unnecessary levels of supervision?**

ADOT may be able to streamline its organizational structure. In fiscal year 1982-83 the Department reduced the number of engineering districts from seven to four in an effort to improve administrative efficiency. Although some positions were eliminated and districts were consolidated, another layer of administration was added in the outlying districts with the creation of nine area offices. A review of the current staffing levels and reporting structure in the districts reveals that spans of control and numbers of staff reporting to area engineers vary among districts. For example, one area engineer supervises 11 orgs, while another supervises only three. In addition, personnel under the area engineers range from approximately 36 to 151 staff. Furthermore, there are at least five levels of supervision in some districts between the district engineer and field crews, yet numbers of org staff are relatively small in some cases. Further audit work is needed to determine if the current organizational structure and reporting hierarchy is necessary and justified.

- **Could ADOT's project scheduling process be improved?**

Discussions with ADOT staff, as well as ADOT documentation and a consultant report, indicate that the Department's project scheduling process needs improvement. Field construction staff have stated that planning labor needs becomes more difficult when project schedules are inaccurate. A 1985 consultant report indicated that ". . . manpower plans will continue to be inaccurate and show excessive manpower needs until the construction letting schedule becomes more accurate." In addition, two ADOT internal memos have revealed problems with ADOT's project scheduling.

Problems with scheduling, among other things, have led the districts to override CEMMS staffing projections with a manually generated manpower report. District engineers have said that they have little faith that project scheduling will become substantially more accurate than it currently is. Further audit work is necessary to determine to what extent the project scheduling process is inaccurate and whether it can be improved.

ARIZONA DEPARTMENT OF TRANSPORTATION

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EVAN MECHAM
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Director

October 29, 1987

Mr. Douglas R. Norton
Auditor General
2700 N. Central Ave., Suite 700
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Dear Mr. Norton:

The following comments constitute our formal response to the most recently revised draft of the performance audit of the Arizona Department of Transportation's Construction Management function. The structure and format of our response is divided into an introduction and general comments, a specific response to each finding, a detailed comment of your supporting analysis, and a specific response to each recommendation.

INTRODUCTION AND GENERAL COMMENTS

The report consists of two findings. The first alleges that ADOT has not adequately controlled construction staffing levels, and the overstaffing cost the state $7.4 million over the last four fiscal years. We totally reject this finding. Further, the inference that $7.4 million has been wasted or resulted in excessive costs to the State of Arizona is not supported by facts.

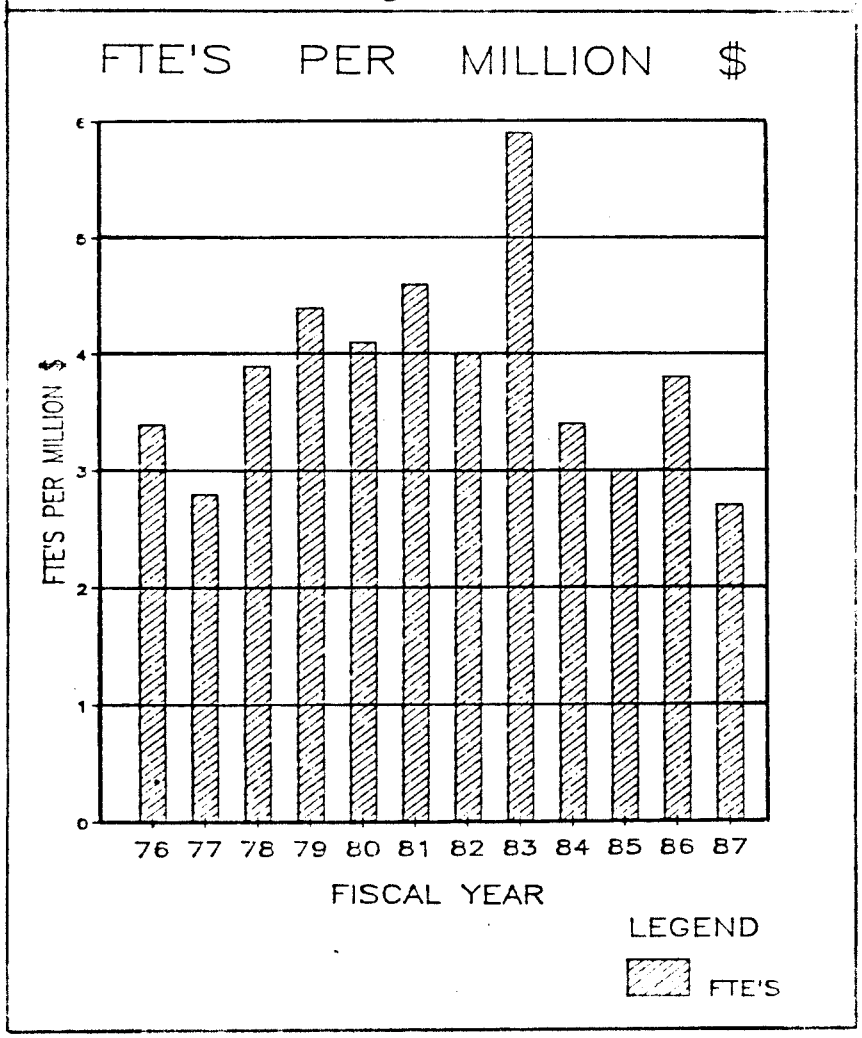
The second finding states that ADOT's Construction Engineering Manpower Management System is not being utilized effectively and needs greater management support. The Construction Engineering Manpower Management System (CEMMS) is a computerized manpower planning and monitoring tool. We concur that it can be used more effectively, and we anticipate the application of additional resources, plus management support, through organizational change.

In order to provide background information that will be germane to the discussion which follows, it is necessary to note that significant change has occurred in the programming level of construction projects over the last four fiscal years. The size of the ADOT construction program has increased significantly.

These changes resulted from a series of funding mechanisms at both the federal and state levels beginning in 1983-84 as a result of the Federal 1982 Surface Transportation Assistance Act. During the same period, significant increases were achieved with an incremental increase in state gasoline taxes, resulting from legislative action in 1982.

Beginning in January 1986 as a result of the previous year's legislation, additional funding was provided for use statewide, and as a result of the half-cent sales tax increase in Maricopa County major construction funding was initiated. These changes resulted in a 155 percent increase in construction contracts advertised and awarded over a five-year period of time. Over that same period the number of employees assigned to field construction contracts varied by only 11.4 percent. The number of full-time construction FTEs per $1 million worth of constant dollar construction was reduced from 5.9 in 1983 to 2.65 in 1987. This indicator of efficiency and productivity per construction employee is shown graphically in Figure 1.

Figure 1



This increased efficiency resulted from a number of innovative techniques developed by the department during that period of time. They significantly affect the analysis and will be discussed in detail further in our response.

SPECIFIC RESPONSE TO FINDING I

The Arizona Department of Transportation does not concur with Finding I. Further, we totally reject the conclusion drawn as a result of the finding. Even if we were to agree with the substance of your methods, manner and conclusion (and we do not), we could not conclude, nor do we agree, that the resources constituted by such alleged overstaffing were not productive for the State of Arizona. The inference that $7.4 million of costs incurred by the State as a result of the alleged overstaffing is not supported by fact. This conclusion infers a waste of manpower, and that has not been the case.

DETAILED COMMENT

The analysis included in the audit report employed three separate methods tabulated in Tables 2, 3 and 5 labeled "The Construction Engineering Cost Method", "Construction Staff Productivity", and "Miscellaneous Time Charged Method" respectively. The results purport to demonstrate overstaffing from 1983 through 1987, ranging from 78 FTEs to 387. You selected the Construction Engineering Cost Method as being the most appropriate.

You noted that utilization of these three separate methods of analysis help to validate your results. It should be pointed out that the three methods utilized in your report yield results that vary from 37 percent to 613 percent. We do not believe such comparison indicates a high probability of verification.

However, we fully recognize the difficulty of finding a specific method that can be utilized in arriving at an appropriate level of construction manpower. Each method can indeed be used if appropriately applied. Each method is analyzed below with appropriate input variables and comment where the analysis is flawed.

1. Construction Engineering Cost Analysis
   In employing the Engineering Cost Analysis you have utilized basic data and information that is utilized in CEMMS. For example, the construction engineering cost goals, which are established for each project and used as a budgeting guide by the Department for engineering manpower, were extracted from each project and applied to specific year's contractor payments. While the system itself is not designed to yield precise numbers of employees to achieve those CE cost goals, it is true one can utilize such an approach, together with

cost per hour data, and back into a calculation of equivalent average number of FTEs per year.

However, any system or formula devised to audit the efficiency of CEMMS in the above analytical setting must be based upon a common foundation with CEMMS. Unfortunately, your analysis is not.

Normal manpower planning assumes sufficient employees to perform specific tasks within a given time period. The accepted practice is to initiate manpower planning on the base of 2,080 hours per year per full-time employee (40 hours/week x 52 weeks/year = 2,080). The standard 2,080 hours/year must be adjusted for annual and sick leave and miscellaneous time.

Historical data shared with your office indicates that within ADOT an average of 291 hours/year per employee is charged against sick and annual leave. Further data, also shared with your office, indicates that an additional 208 hours per year per employee are charged to non-construction and other valid, productive assignments not directly related to construction. Therefore, the total number of hours/year per employee available to construction activities in CEMMS is 1,581 (2,080 - 291 - 208 = 1,581). This figure must be used for "Hours per Year" if an accurate analysis is to be performed.This differs significantly with the value of 1,789 hours per year available as per your calculation in Table 2. Thus, the results obtained utilizing the more appropriate 1,581 hours per year as noted above are set forth in Figure 2.

Figure 2

Construction staff as determined by an analysis of Construction Engineering (CE) costs for FY 1983-84 through 3/4 of FY 1986-87

FISCAL YEAR	CONTRACTOR(a) PAYMENTS	CE (b) GOAL	CE COST GOAL	COST PER(c) HOUR	HOURS NEEDED	HOURS PER(d) YEAR	STAFF(e) NEEDED	vs	ACTUAL(f) STAFF	STAFF DIFFERENCE
1983-84	$165,481,277.30	x 8.70% =	$14,396,871.13 /	$16.18 =	$889.794.26 /	1,581 =	563	vs	544	(19)
1984-85	$202,097,225.12	x 8.14% =	$16,450,714.12 /	$17.21 =	$955,881.12 /	1,581 =	605	vs	591	(14)
1985-86	$184,652,465.89	x 8.54% =	$15,769,320.59 /	$17.17 =	$918,422.86 /	1,581 =	581	vs	614	33
1986-87	$179,807,627.33	x 7.85% =	$14,114,898.75 /	$18.63 =	$757,643.52 /	1,186 =	639	vs	586	(53)

(a) Excludes projects administered by private consulting firms. (Auditor General determined)
(b) Overall goal based on cummulative application of ADOT CE cost goals. (Auditor General Determined)
(c) ADOT-determined average cost per man hour for the fiscal year. (Based on CEMMS standard of 2080 hrs/year)
(d) Average number of construction engineering hours worked per year by one employee. (Base of 2080 hrs/year)
(e) Does not include staff needed to oversee consultant managed projects.
(f) Does not include staff, which oversee consultant managed projects. (Auditor General determined)

Utilizing the same data and methodology as set forth in your Table 2 with this one change, we find that the Department was not overstaffed, with the exception of FY 1985-86. In this instance, projects were not advertised and awarded as originally scheduled, because approximately $45 million worth of projects were delayed. This delay resulted from application of the Grahamm-Rudman-Hollings bill and budget deficit procedure at the federal level. We readily admit we did not adjust our work force for this short period of time, because of the complexities of training and acquiring construction inspection personnel.

As shown in Figure 2, ADOT has used CEMMS properly to plan and control our construction staff over the past four years. In fiscal years other than 1985-86 ADOT has been slightly understaffed in construction, resulting in a total opportunity cost savings of $1,869,379 as shown in Figure 3.

Figure 3

COST OF CONSTRUCTION STAFF
FISCAL YEARS 1983-84 THROUGH 1986-87

FISCAL YEAR	STAFF DIFFERENCE	AVERAGE STAFF WAGE COST	WAGE COST DIFFERENCE
1983-84	(19)	$31,115.00	$591.185.00
1984-85	(14)	$33,129.00	$463.806.00
1985-86	33	$33,045.00	($1,090,485.00)
1986-87	(53)	$35,941.00	$1,904,873.00
TOTAL	(53)	SAVINGS	$1,869,379.00

2. <u>Productivity Method of Calculation</u>

In addition to the above-noted consideration regarding the average yearly staff hours available, the analysis labeled "Staff Productivity" in Table 3 of your report utilizes another factor which warrants comment. The productivity standard factor ($163.17) is noted to be the highest level of productivity achieved by ADOT to date. That productivity was achieved in the fiscal year just completed and validates the productivity and efficiency increases shown in our Figure 1. However, this analysis requires some further comment.

During the past four fiscal years significant innovative techniques have been implemented by the Department, which affect the construction engineering manpower efficiency. The

Department has developed and initiated specifications requiring "end result" acceptance of Portland cement concrete and asphaltic concrete, totally changing the manpower required for the Department to monitor and control the production of these two materials. As a result of those specification changes, the construction industry itself has grown increasingly more proficient in the control of its own operation. Both have resulted in a lesser amount of manpower required in behalf of the Department.

During the same period, the Department initiated and implemented "contractor staking" of construction projects. This has reduced significantly the construction manpower requirements. The significant point here is that the productivity achieved in the past year is not a level that would have been applicable to previous years, because of the changes made in the method in which these activities were carried out. Thus, the application of the productivity factor of $163.17 to years prior to the current year yields results which are inaccurate.

3. Miscellaneous Time Analysis

Inasmuch as the miscellaneous time factor, when utilized and reported properly, is an indicator of only those hours of productive time spent on non-direct project-chargeable activities, we agree it is a tool for utilization by the local level manager as well as Central Office staff to judge activities, but it is not an indicator of efficiency.

To summarize, we believe our analysis set forth in Figure 2 is the most realistic approach that can be achieved when utilizing these methods. From the information available to the Department, we do not believe a finding of overstaffing is valid with the exception of the one year indicated. Retention of trained staff until additional work became available was an entirely appropriate approach to the management of the construction engineering manpower.

RECOMMENDATIONS

Following is the Arizona Department of Transportation's response relative to the recommendations for Finding I.

1. ADOT should consider increasing its use of alternative staffing methods as needed to handle peak construction periods statewide and in seasonal districts before adding additional permanent staff.

Response:

- Use of Consulting Engineers
The Arizona Department of Transportation will continue to utilize consulting engineers as staff extensions where appropriate. We deem this activity to be appropriate where peak workloads exist and, more importantly, where unique construction activity requires expertise which we do not maintain within our staff. We do not, however, anticipate expanding greatly the utilization of consulting engineers, because this approach is not the most cost-effective or proficient in terms of professional service rendered.

- Contracting Out of Functions
ADOT currently provides for "contractor staking" and has for the past two years. Certain laboratory functions and inspection are also contracted out. We will continue these practices.

- Use of Temporary Staff
We have in the past and will continue to utilize temporary staff.

- District Transfers
We have in the past and will continue to utilize staff transfers where appropriate.

- Share Resources With Maintenance
While we have used construction personnel to supplement maintenance, particularly in the winter season, there is very little opportunity to reverse that trend and utilize maintenance work forces for construction. This inability results from the training required for construction inspection technicians as well as the staffing of maintenance crews which require a full complement based upon the annual maintenance plan.

2. The Legislature should consider setting and monitoring ADOT construction staff levels.

Response:
The Department does not oppose working with the Legislature on this matter. It must be realized, however, that a significant degree of flexibility would be necessary in order to meet the fluctuations in construction funding which occur on extremely short notice--particulary in the federal program. For example, the Department received approximately $299 million in additional discretionary federal funds for Interstate construction over the past few years. These funds must be placed in construction status within 90 days of receipt. Accordingly, the normal budget cycle is such that initial budget requests are prepared and submitted 23 months before the end of the fiscal year in which they are to be utilized.

3. The Legislature should consider acquiring a followup performance audit in two years of ADOT's construction management function to review its progress in managing staff size.

   Response:
   The Department welcomes a followup review of this activity at any time.

RESPONSE TO FINDING II

Finding II deals with the Construction Engineering Manpower Management System (CEMMS) utilized by ADOT. We agree this system could be utilized more effectively. The CEMMS system was initiated by the Arizona Department of Transportation in 1982. Like many other systems developed in the last decade to assist in managing transportation and highway department operations, the basic goal has been to take normal management techniques together with appropriate criteria and automate them through the use of software and computers. The validity of such systems, however, and thus their usefulness, depends upon their simplicity.

In other words, to be utilized effectively and willingly by management at all levels such systems must provide a useful tool without overburdening them with either input or output data. With this in mind, it is the intent of ADOT to review critically the overall function of the CEMMS system with the objective of strengthening it. Further, it will be the objective of management to ensure proper utilization of all applicable line managers.

RECOMMENDATIONS

1. ADOT should strongly support the CEMMS program, requiring full utilization by both central office and district management.

   Response:

   ADOT has supported CEMMS in the past and will continue to increase that support in the future through organizational changes, which are being considered.

2. ADOT should provide adequate resources to properly carry out the CEMMS program at the central office, district and area levels.

   Response:
   The approach we intend to take in improving CEMMS utilization should require minimal increased resources. However, those required will be made a budget issue for FY 1988-89.

3. The ADOT director should require that sufficient support be given CEMMS by the ADOT Information Systems Group.

   Response:
   Where data processing systems modifications and programming are required by CEMMS, ADOT management will utilize ISG personnel or outside expertise as deemed to be most cost effective.

4. ADOT should:
   * Address current CEMMS deficiencies and direct that adequate analysis and modifiction of the System be accomplished.
   * Clearly define the CEMMS program goals and objectives.
   * Specify the responsibilities of each organizational level, from senior management to field staff.
   * Reassert central office management's role in setting statewide labor levels.
   * Make provisions for more management analysis at both the central office and district levels.

   Response:
   All five objectives outlined in the above recommendation will be accomplished.

Sincerely,

Charles L. Miller
Director

CLM:VN