

Title:Linear Programming Model to Assist in Planning ProjectExecution

Course: Year: 1993 Author(s): C. Jones, G. Jones and M. Snyder

Report No: P93021

	ETM OFFICE USE ONLY
Report No.:	See Above
Type:	Student Project
Note:	This project is in the filing cabinet in the ETM department office.

Abstract: We developed a linear model of a project outlining labor requirements for staff utilization and budget constraints for budget allocation. The linear model was solved by linear programming techniques which allocated labor requirements and determined which tasks could not be completed due to insufficient staff.

Linear Programming Model to Assist in Planning Project Execution

Greg Jones Cliff Jones Mark Snyder

~

EMP-P9321

LINEAR PROGRAMMING MODEL TO ASSIST IN PLANNING PROJECT EXECUTION

P 9 2 |

ø

EMGT 540, Spring Term 1993 GREG JONES, CLIFF JONES, MARK SNYDER

t

EXECUTIVE SUMMARY

The objective, was to develop a linear programming model to assist in planning project execution for an engineering consulting firm. Planning project execution has many elements, two of which are staff utilization and budget allocations. Staff utilization is constrained by the number and type of staff (i.e., appropriate engineering discipline and grade) available for assignment to various tasks within the project. Budget allocation is constrained by the labor dollars estimated to complete a project, which is directly related to labor hours required to complete the separate tasks that make up the project. These are further constrained by different billing rates and utilization goals for staff of different grades and disciplines. However, on most tasks, there is the option of using staff of several different disciplines and grades to perform the required work.

The classical method of planning project execution with staff and budget constraints is utilizing a spread sheet and iterating by trial and error until a project is staffed within budget. This is a labor intensive task and for larger project may need to be completed several times. However, for initial planning or where detailed staffing estimates are not required, a load level estimate may be utilized. A load level estimate is an estimate in which actual available staff are assigned on a percentage of time available and detailed assignment and schedule are not required. This allows for a determination of company staff allocation required and also indicates staffing or budgeting problems. A linear model can be used in a load level estimate which then can be solved by linear programming techniques.

In the development of the model, a project was identified requiring eight different tasks, a six-month project duration, employees from ten different disciplines and grade levels, and

INTRODUCTION

Initially, project planning is started during the proposal scoping and budgeting phase. The staff requirements and budget estimates are determined before consideration of the availability of staff is determined. Usually, general company disciplines and grades are used during the proposal stage without consideration to available staff. If the proposal was successful the next stage is planning project execution. Planning project execution has many elements, two of which are company staff resources and budget considerations. Company staff utilization is constrained by the number and type of staff available for assignment to various tasks (i.e., appropriate engineering discipline and grade). Budget utilization is constrained by the labor dollars estimated to complete a task, which is directly related to labor hours required to complete a task. These are further constrained by different billing rates and utilization goals for staff of different grades and disciplines. However, on most projects, there is the option of using staff of several different disciplines and grades to perform the required work.

The classical method of planning project execution with staff and budget constraints is utilizing a spread sheet and iterating by trial and error until a project is staffed within budget. This is a labor intensive task and for larger project may need to be completed several times. However, for initial planning or where detailed staffing estimates are not required, a load level estimate may be utilized. A load level estimate is an estimate in which actual available staff are assigned on a percentage of time available and detailed assignment and schedule are not required. This allows for a determination of company staff allocation required and also indicates staffing or budgeting problems. A linear model can be used in a load level estimate which then can be solved by linear programming techniques.

STAFFING REQUIREMENT PER MONTH

Key disciplines Needed Disciplines

Quarter A			Quarter B		
Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
•					
Task 1					
ES3, EN1, HY2	ES2, EN1, HY2	ES2, EN1, HY2			
ES3, EN1, HY2,	ES3, EN1, HY2,	ES3, EN1, HY2,			
EN4, EN3, EN2,	EN4, EN3, EN2,	EN4, EN3, EN2,			
	Task 2			1	
	TE3	TE3	TE3		
	TE3, HY4, EN3,	TE3, HY4, EN3,	TE3, HY4, EN3,		
	EN4, EN2	EN4, EN2	EN4, EN2		
		Visite 1			
	Task 3	*		•	
	HY2	HY2	HY2		
	HY2, EN4, EN3,	HY2, EN4, EN3,	HY2, EN4, EN3,		
	HY4, HY1, HY3	HY4, HY1, HY3	HY4, HY1, HY3		
	Task 4				
	HY3	HY3	HY3	HY3	<u>*</u>
	HY3, EN4, EN3,	HY3, EN4, EN3,	HY3, EN4, EN3,	HY3, EN4, EN3,	
	HY4, HY1, HY2	HY4, HY1, HY2	HY4, HY1, HY2	HY4, HY1, HY2	
					•
		Task 5			
		ES3, EN2, EN1	ES3, EN2, EN1	ES3, EN2, EN1	
		ES3, EN2, EN1,	ES3, EN2, EN1,	ES3, EN2, EN1,	
		EN3, EN4,	EN3, EN4,	EN3, EN4,	

,

BUDGET REQUIREMENTS PER TASK



CONSTRAINTS - QUARTER A

Constraint 1: Labor budget available per task with assigned staff.

Task 1:

25.07EN3P1M1 + 25.07EN3P1M2 + 25.07EN3P1M3 + 26.95EN4P1M1

+ 26.95EN4P1M2 + 26.95EN4P1M3 <= 4827.6

Any combination of EN3/EN4 can be used for this task, but total charges cannot exceed 15% of the task's budget.

18.47EN2P1M1 + 18.47EN2P1M2 + 18.47EN2P1M3 >= 1609.2

An EN2 must charge at least 5% of the task's budget.

18.47EN2P1M1 + 18.47EN2P1M2 + 18.47EN2P1M3 + 18.26EN1P1M1 + 18.26EN1P1M2 + 18.26EN1P1M3 + 21.57ES3P1M1 + 21.57ES3P1M2 + 21.57ES3P1M3 + 21.63HY2P1M1 + 21.63HY2P1M2 + 21.63HY2P1M3 <= 25747.2 Any combination of EN2/EN1/ES3/HY2 can be used for this task, but total charges cannot

Any combination of EN2/EN1/ES3/HY2 can be used for this task, but total charges canno exceed 80% of the task's budget.

Task 2:

23.35HY4P2M2 + 23.35HY4P2M3 <= 290.27

An HY4 cannot charge more than 5% of the task's budget.

25.07EN3P2M2 + 25.07EN3P2M3 + 26.95EN4P2M2 + 26.95EN4P2M3 <= 580.53

Any combination of EN3/EN4 can be used for this task, but total charges cannot exceed 10% of the task's budget.

À

Task 5:

25.07EN3P5M3 + 26.95EN4P5M3 <= 686.7

Any combination of EN3/EN4 can be used for this task, but total charges cannot exceed 10% of the task's budget.

À

18.47EN2P5M3 >= 343.35

An EN2 must charge at least 5% of the task's budget.

18.47EN2P5M3 + 18.26EN1P5M3 + 21.57ES3P5M3 <= 5836.95

Any combination of EN2/EN1/ES3 can be used for this task, but total charges cannot exceed 85% of the task's budget.

Task 6:

25.07EN3P6M3 + 26.95EN4P6M3 <= 186.1

Any combination of EN3/EN4 can be used for this task, but total charges cannot exceed 10% of the task's budget.

18.47EN2P6M3 >= 93.05

An EN2 must charge at least 5% of the task's budget.

18.47EN2P6M3 + 21.57ES3P6M3 <= 1581.85

Any combination of EN2/ES3 can be used for this task, but total charges cannot exceed 85% of the task's budget.

-0.003HY1 + 0.0021HY2 <= 0

An HY2 cannot use a higher percentage of available hours than an HY1.

Constraint 3: Labor hours utilized cannot exceed labor hours available for the quarter.

 $EN1 \le 494$ $EN2 \le 468$ $EN3 \le 442$ $EN4 \le 312$ $HY1 \le 494$ $HY2 \le 468$ $HY3 \le 442$ $HY4 \le 390$ $ES3 \le 442$ $TE3 \le 494$

Constraint 4: Total labor hours utilized per employer labor grade.

- EN1 + EN1P1M1 + EN1P1M2 + EN1P1M3 + EN1P5M3 = 0

- EN2 + EN2P1M1 + EN2P1M2 + EN2P1M3 + EN2P2M2 + EN2P2M3 + EN2P5M3 +

EN2P6M3 + EN2P8M3 = 0

- EN3 + EN3P1M1 + EN3P1M2 + EN3P1M3 + EN3P2M2 + EN3P2M3 + EN3P3M2 +

EN3P3M3 + EN3P4M2 + EN3P4M3 + EN3P5M3 + EN3P6M3 + EN3P8M3 = 0

- EN4 + EN4P1M1 + EN4P1M2 + EN4P1M3 + EN4P2M2 + EN4P2M3 + EN4P3M2 +

EN4P3M3 + EN4P4M2 + EN4P4M3 + EN4P5M3 + EN4P6M3 + EN4P8M3 = 0

- HY1 + HY1P3M2 + HY1P3M3 + HY1P4M2 + HY1P4M3 + HY1P8M3 = 0

Constraint 6: Labor hours per grade can not exceed available per month. (No over time.) For example, EN4's work on Tasks 1,2,3,4,5,6, and 8 cannot exceed 103 hours.

EN1P1M1 <= 164.3333 EN1P1M2 <= 164.3333 $EN1P1M3 + EN1P5M3 \le 164.3333$ $EN2P1M1 \le 156$ $EN2P1M2 + EN2P2M2 \le 156$ EN2P1M3 + EN2P2M3 + EN2P5M3 + EN2P6M3 + EN2P8M3 <= 156EN3P1M1 <= 147.3333 EN3P1M2 + EN3P2M2 + EN3P3M2 + EN3P4M2 <= 147.3333 EN3P1M3 + EN3P2M3 + EN3P3M3 + EN3P4M3 + EN3P5M3 + EN3P6M3 + EN3P8M3 <= 147.3333 EN4P1M1 <= 103 EN4P1M2 + EN4P2M2 + EN4P3M2 + EN4P4M2 <= 103 EN4P1M3 + EN4P2M3 + EN4P3M3 + EN4P4M3 + EN4P5M3 + EN4P6M3 $+ EN4P8M3 \le 103$ $HY1P3M2 + HY1P4M2 \le 164.6667$ HY1P3M3 + HY1P4M3 + HY1P8M3 <= 164,6667 $HY2P1M1 \le 156$ $HY2P1M2 + HY2P3M2 + HY2P4M2 \le 156$ $HY2P1M3 + HY2P3M3 + HY2P4M3 + HY2P8M3 \le 156$ $HY3P3M2 + HY3P4M2 \le 147.3333$ HY3P3M3 + HY3P4M3 <= 147.3333 $HY4P2M2 + HY4P3M2 + HY4P4M2 \le 130$ $HY4P2M3 + HY4P3M3 + HY4P4M3 \le 130$ $ES3P1M1 \le 147.3333$

TASK 6

25.07 EN3P6M4 + 25.07 EN3P6M5 + 25.07 EN3P6M6 + 26.95 EN4P6M4 + 26.95 EN4P6M5 + 26.95 EN4P6M6 <= 558.3

Any combination of EN3/EN4 can be used for this task, but total charges cannot exceed 10% of the task's budget.

21.57 ES3P6M4 + 21.57 ES3P6M5 + 21.57 ES3P6M6 + 18.47EN2P6M4 + 18.47 EN2P6M5 +

A

18.47 EN2P6M6 <= 4745.55

Any combination of EN2/ES3 can be used for this task, but total charges cannot exceed 85% of the task's budget.

TASK 7

25.07 EN3P7M5 + 25.07 EN3P7M6 + 26.95 EN4P7M5 + 26.95EN4P7M6 <= 3678.6

Any combination of EN3/EN4 can be used for this task, but total charges cannot exceed 10% of the task's budget.

18.47 EN2P7M5 + 18.47 EN2P7M6 + 21.57 ES3P7M5 + 21.57ES3P7M6 + 16.33 GO2P7M5 +

16.33 GO2P7M6 <= 31268.1

Any combination of EN2/ES3/GO2 can be used for this task, but total charges cannot exceed 85% of the task's budget.

TASK 8

18 HY1P8M4 + 18 HY1P8M5 + 21.63 HY2P8M4 + 21.63 HY2P8M5 <= 1409.67

Any combination of HY1/HY2 can be used for this task, but total charges cannot exceed 20% of the task's budget.

Constraint 3: Labor hours utilized cannot exceed labor hours available for the quarter.

The total quarterly hours available for all personnel.

 $EN1 \le 494$ $EN2 \le 468$ $EN3 \le 442$ $EN4 \le 312$ $HY1 \le 494$ $HY2 \le 468$ $HY3 \le 442$ $HY4 \le 390$ $ES3 \le 442$ $GO2 \le 468$ $TE3 \le 494$

Constraint 4: Total labor hours utilized per staff labor grade.

- EN1 + EN1P5M4 + EN1P5M5 = 0
- EN2 + EN2P2M4 + EN2P5M4 + EN2P5M5 + EN2P6M4 + EN2P6M5 + EN2P6M6 +
 EN2P7M5 + EN2P7M6 + EN2P8M4 + EN2P8M5 = 0
- EN3 + EN3P2M4 + EN3P3M4 + EN3P4M4 + EN3P4M5 + EN3P5M4 + EN3P5M5 +
 EN3P6M4 + EN3P6M5 + EN3P6M6 + EN3P7M5 + EN3P7M6 + EN3P8M4 +
 EN3P8M5 = 0
- EN4 + EN4P2M4 + EN4P3M4 + EN4P4M4 + EN4P4M5 + EN4P5M4 + EN4P5M5 +
 EN4P6M4 + EN4P6M5 + EN4P6M6 + EN4P7M5 + EN4P7M6 + EN4P8M4 +
 EN4P8M5 = 0

- HY2 + HY2P3M4 + HY2P4M4 + HY2P4M5 + HY2P8M4 + HY2P8M5 = 0

 $EN3P8M4 \ge 49.1111$ $EN3P8M5 \ge 49.1111$

Constraint 6: Labor hours per grade can not exceed available per month. (No over time.)

For example, EN4's work on Tasks 2,3,4,5,6, and 8 cannot exceed 104 hours."

- EN1P5M4 <= 164.6667
- EN1P5M5 <= 164.6667

EN2P2M4 + EN2P5M4 + EN2P6M4 + EN2P8M4 <= 156

EN2P5M5 + EN2P6M5 + EN2P7M5 + EN2P8M5 <= 156

 $EN2P6M6 + EN2P7M6 \le 156$

EN3P2M4 + EN3P3M4 + EN3P4M4 + EN3P5M4 + EN3P6M4 + EN3P8M4 <= 147.3333

EN3P4M5 + EN3P5M5 + EN3P6M5 + EN3P7M5 + EN3P8M5 <= 147.3333

EN3P6M6 + EN3P7M6 <= 147.3333

EN4P2M4 + EN4P3M4 + EN4P4M4 + EN4P5M4 + EN4P6M4 + EN4P8M4 <= 104

EN4P4M5 + EN4P5M5 + EN4P6M5 + EN4P7M5 + EN4P8M5 <= 104

 $EN4P6M6 + EN4P7M6 \le 104$

HY1P3M4 + HY1P4M4 + HY1P8M4 <= 164.6667

HY1P4M5 + HY1P8M5 <= 164.6667

HY2P3M4 + HY2P4M4 + HY2P8M4 <= 156

 $HY2P4M5 + HY2P8M5 \le 156$

HY3P3M4 + HY3P4M4 <= 147.3333

HY3P4M5 <= 147.3333

 $HY4P2M4 + HY4P3M4 + HY4P4M4 \le 130$

HY4P4M5 <= 130

 $ES3P5M4 + ES3P6M4 \le 147.3333$

ES3P5M5 + ES3P6M5 + ES3P7M5 <= 147.3333

DEFINITION OF VARIABLES - QUARTER A

Variable definition: HY3P1M1

HY3 P1 M1 month Task number Discipline & grade level

- EN1 Total hours assigned for an Engineer, Grade 1 (EN1)
- EN1P1M1 Hours EN1 assigned to Task 1 in month 1
- EN1P1M2 Hours EN1 assigned to Task 1 in month 2
- EN1P1M3 Hours EN1 assigned to Task 1 in month 3
- EN1P5M3 Hours EN1 assigned to Task 5 in month 3 *
- EN2 Total hours assigned for an Engineer, Grade 2 (EN2)
- EN2P1M1 Hours EN2 assigned to Task 1 in month 1
- EN2P1M2 Hours EN2 assigned to Task 1 in month 2
- EN2P1M3 Hours EN2 assigned to Task 1 in month 3
- EN2P2M2 Hours EN2 assigned to Task 2 in month 2
- EN2P2M3 Hours EN2 assigned to Task 2 in month 3
- EN2P5M3 Hours EN2 assigned to Task 5 in month 3
- EN2P6M3 Hours EN2 assigned to Task 6 in month 3
- EN2P8M3 Hours EN2 assigned to Task 8 in month 3

- HY1 Total hours assigned for a Hydrologist, Grade 1 (HY1)
- HY1P3M2 Hours HY1 assigned to Task 3 in month 2
- HY1P3M3 Hours HY1 assigned to Task 3 in month 3
- HY1P4M2 Hours HY1 assigned to Task 4 in month 2
- HY1P4M3 Hours HY1 assigned to Task 4 in month 3
- HY1P8M3 Hours HY1 assigned to Task 8 in month 3
- HY2 Total hours assigned for a Hydrologist, Grade 2 (HY2)
- HY2P1M1 Hours HY2 assigned to Task 1 in month 1
- HY2P1M2 Hours HY2 assigned to Task 1 in month 2
- HY2P1M3 Hours HY2 assigned to Task 1 in month 3
- HY2P3M2 Hours HY2 assigned to Task 3 in month 2
- HY2P3M3 Hours HY2 assigned to Task 3 in month 3
- HY2P4M2 Hours HY2 assigned to Task 4 in month 2 '
- HY2P4M3 Hours HY2 assigned to Task 4 in month 3
- HY2P8M3 Hours HY2 assigned to Task 8 in month 3
- HY3 Total hours assigned for a Hydrologist, Grade 3 (HY3)
- HY3P1M1 Hours HY3 assigned to Task 1 in month 1
- HY3P1M2 Hours HY3 assigned to Task 1 in month 2
- HY3P1M3 Hours HY3 assigned to Task 1 in month 3
- HY3P3M2 Hours HY3 assigned to Task 3 in month 2
- HY3P3M3 Hours HY3 assigned to Task 3 in month 3
- HY3P4M2 Hours HY3 assigned to Task 4 in month 2
- HY3P4M3 Hours HY3 assigned to Task 4 in month 3

DEFINITION OF VARIABLES - QUARTER B

DEFINITION OF VARIABLES - QUARTER B

Variable definition: HY3P1M4

HY3 P1 M4 month Task number Discipline & grade level

- EN1 Total hours assigned for an Engineer, Grade 1 (EN1)
- EN1P5M4 Hours EN1 assigned to Task 5 in month 4
- EN1P5M5 Hours EN1 assigned to Task 5 in month 5
- EN2 Total hours assigned for an Engineer, Grade 2 (EN2)
- EN2P2M4 Hours EN2 assigned to Task 2 in month 4
- EN2P5M4 Hours EN2 assigned to Task 5 in month 4
- EN2P5M5 Hours EN2 assigned to Task 5 in month 5
- EN2P6M4 Hours EN2 assigned to Task 6 in month 4
- EN2P6M5 Hours EN2 assigned to Task 6 in month 5
- EN2P6M6 Hours EN2 assigned to Task 6 in month 6
- EN2P7M5 Hours EN2 assigned to Task 7 in month 5
- EN2P7M6 Hours EN2 assigned to Task 7 in month 6
- EN2P8M4 Hours EN2 assigned to Task 8 in month 4
- EN2P8M5 Hours EN2 assigned to Task 8 in month 5

DEFINITION OF VARIABLES - QUARTER B

3 \$

EN4P8M4	Hours EN4 assigned to Task 8 in month 4
EN4P8M5	Hours EN4 assigned to Task 8 in month 5
HY1	Total hours assigned for a Hydrologist, Grade 1 (HY1)
HY1P3M4	Hours HY1 assigned to Task 3 in month 4
HY1P4M4	Hours HY1 assigned to Task 4 in month 4
HY1P4M5	Hours HY1 assigned to Task 4 in month 5
HY1P8M4	Hours HY1 assigned to Task 8 in month 4
HY1P8M5	Hours HY1 assigned to Task 8 in month 5
HY2	Total hours assigned for a Hydrologist, Grade 2 (HY2)
HY2P3M4	Hours HY2 assigned to Task 3 in month 4
HY2P4M4	Hours HY2 assigned to Task 4 in month 4
HY2P4M5	Hours HY2 assigned to Task 4 in month 5
HY2P8M4	Hours HY2 assigned to Task 8 in month 4
HY2P8M5	Hours HY2 assigned to Task 8 in month 5
HY3	Total hours assigned for a Hydrologist, Grade 3 (HY3)
HY3P3M4	Hours HY3 assigned to Task 3 in month 4
HY3P4M4	Hours HY3 assigned to Task 4 in month 4
HY3P4M5	Hours HY3 assigned to Task 4 in month 5
HY4	Total hours assigned for a Hydrologist, Grade 4 (HY4)
HY4P2M4	Hours HY4 assigned to Task 2 in month 4
HY4P3M4	Hours HY4 assigned to Task 3 in month 4
HY4P4M4	Hours HY4 assigned to Task 4 in month 4
HY4P4M5	Hours HY4 assigned to Task 4 in month 5

SOLUTION

The linear programming output for Quarter A and B are presented in Appendix A and B, respectively. The linear model was solved using LINDO, a standard linear programming computer software package. The solution to the linear model is presented below.

The solution of the objective function which outline utilized direct labor is:

Quarter A: \$61,592 out of \$62,991, a utilization of 98%

Quarter B: \$53,150 out of \$73,311, a utilization of 72%

Project: \$114,742 out of \$136,302, a utilization of 84%

The break down of staffing hours per month is shown in the following table. The table shows actual utilized direct labor as determined by the model and the actual total available hours for the month as developed for the constraints.

Actual utilized hours for the month Total available hours for the month

SENSITIVITY ANALYSIS

SENSITIVITY ANALYSIS

With this direct labor utilization linear model there are only two sensitivity variables that need to be reviewed. The slack in the task budget constraints and the shadow prices for the staff.

The slack in the task budget constraint will identify which task are not fully utilizing their direct labor budget and require additional staffing hours in order to complete the task.

The shadow price of the staff will indicates which staff position can be added to improve the objective function, utilized direct labor, range on the variables in question will identify the maximum number of hours that can be added.

Task	Slack	Disciplines	Months
		involved	involved
5	\$680.13	EN2, EN1, ES3	3
6	\$621.41	EN2 and ES3	3
7	\$20,163.39	EN2, ES3, GO2	5 and 6

The following three tasks did not fully utilize their respective task budgets.

The following staff during the assigned months have a shadow price, which identifies hours during the month that can be added and will increase the utilized direct labor.

RESULTS

The results of the linear model for the project came out very well with 84% of the direct labor budget being utilized with three task not fully utilizing their respective budgets. The remaining 16% was largely in one task and this task will need to have more staff added in order to complete the work.

The output can be analyzed to determines what hours are available for allocation to other projects. With this project, the technical engineering hours are fully utilized. The slack hours are in management hours, which can be used on new projects or other managerial duties.

In order to increase the utilization of the direct labor budget to 100%. The shadow price (dual prices) and ranges on the right hand side (b) values (right hand side) which determines which staffing position need more hours. There are a number of disciplines and months that have a shadow price which by adding hours will increase the objective function and get closer to 100% utilization. The range on that staff position for that month when adding hours. Next, find which task would absorb the additional hours.

For example:

Task 5 and 6 can use some more hours in month 3, can not exceed \$680.13 and \$621.41, respectively. A staff with a marginal value and a upper increase on range greater then zero must be identified. The best selection would be EN2, which would add 36.82 hours at a rate of 18.47 per hour or a total increase of 680.06. There are many different task allotments that could be used but the most straight forward would be assign the full 36.82 hours to task 5, decreasing task 5 slack to \$0.07. If task 6 had a higher priority then the allot scheme could be 34 hours to task 5 and 2.82 hours to task 6. This would decease slack on task 6 and task 5 to 0 and 628.58

 Increase the number of projects included in the model. Include more projects in the model to absorb the surplus hours in the management personal. In order to add more projects, additional technical hours will also need to be added. This would change the model from a project execution model to a departmental or division planning model.

The previously listed extensions would enable the model to more accurately display the actual execution of a project.

CONCLUSION

As outline previously the classical method of planning project execution with staff and budget constraints is utilizing a spread sheet and iterating by trial and error until a project is staffed within budget. This is a labor intensive task and for larger project may need to be completed several times. However, for initial planning or where detailed staffing estimates are not required, a load level estimate may be utilized. A load level estimate is an estimate where actual company staff who are available are assigned on a percentage of time available and detailed assignment and schedule are not required. The objective of the model was to determine staff allocation required and also indicate staffing or budget problems. A linear model can be used in a load level estimate which then can be solved by linear programming techniques.

The linear model which was developed satisfied its objective of identifying staff which were either completely utilized or under utilized by task within the project. The model also identified which tasks could not be completed because of insufficient labor hours and which categories and grades should be added to increase labor utilization. The model modifications as outlined in the discussion of possible extensions would enable the project planning to go a step further in staff allocation.