ETM
ENGINEERING & TECHNOLOGY MANAGEMENT

Title: Service Water System Balance at Trojan Nuclear Plant

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Abstract: The Service Water System at the Trojan Nuclear Plant provides cooling water to various safety-related systems and equipment. The system uses Columbia River water and is prone to silt build up, which degrades flow, and requires periodic line flushing. This project examines a portion of the Service Water System which serves eight safety-related room coolers aligned in parallel, in order to determine the most desirable combination of flows through the coolers. We model the flow network as a linear system in the flow range of interest, based on operations knowledge of system behavior, and the model was solved to optimize total flow to the coolers of interest by using Linear Programming method.

B-Train Service Water Flow Balance

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Abstract

The Service Water System at the Trojan Nuclear Plant provides cooling water to various safety-related systems and equipment. The system uses Columbia River water and is prone to silt buildup which degrades flow, requiring periodic line flushing.

This project examined a portion of the Service Water System which serves eight safety-related room coolers aligned in parallel, in order to determine the most desirable combination of flows through the coolers. The project modeled the flow network as a linear system in the flow range of interest, based on operations knowledge of system behavior.

The model was solved using linear programming computer software which optimized total flow to the coolers of interest. Because the flow was not adequately balanced between the coolers, several refinements to the model were made by incorporating goals for specific flows. By successive refinements, a solution was calculated which involved a tradeoff between total flow and balancing of flow between the coolers.

The effect of changing flow resistance in one line was modeled. This model showed that changes to one line had only small effects on other lines in the system. In all cases flow was easily diverted to the first several coolers in the line, while forcing flow through the end coolers involved a penalty on overall flow.

Further modeling of a larger system could be performed in the same manner as for this project, but it was felt that such a model could easily suffer from inaccuracy due to the large number of empirical constraints, each based on operational experience.

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1.0 Executive Summary

During the 1991 Refueling and Maintenance Outage at the Trojan Nuclear Plant, modifications will be made to the Service Water System, a system which provides cooling water to various safety-related systems and equipment. As part of the justification for system operability at power, a test is to be performed which balances flows throughout the system. The test is expected to be on the critical path for plant restart, so that an estimate of target flows is desirable prior to altering flows. Each cooling load has a specific minimum flow requirement which must be met.

The Service Water System has experienced silting problems due to the use of Columbia River water high in particulates. One portion of the system particularly prone to silting is a set of eight room coolers aligned in parallel. This project created a linear network flow model of these coolers, with the goal of maximizing overall flow while balancing flow among the coolers. The maximum overall flow is desirable to reduce silting. A balanced flow is also desired to provide flow margins above design minimum in all cooler lines.

Solving the original flow model maximized total flow but gave an unbalanced set of individual flows, with two lines at design minimum. Successive model refinements were made by introducing flow margin goals on coolers which were the most difficult to balance. A compromise was made between overall flow and flow balance. The most satisfactory solution tolerated a 5.8% reduction in overall flow so that all flow margins were above 3.1%. The goal of providing a 10% margin on the cooler most prone to silting problems was not met by this flow combination, but a 7% margin was calculated and deemed acceptable.

2.0 Background

The Trojan Nuclear Plant uses many piping systems to support plant operation. The Service Water System (SWS) supplies cooling water to various plant systems and equipment. Part of this system is classified as "safety-related," which indicates that the system is necessary to achieve and maintain safe plant shutdown. Safety-related systems typically are separated into two trains (A and B) as a design strategy which creates a redundant and diverse ability for the system to perform its safety-related function. Each train is individually capable of performing the safety-related function of the system.

The SWS serves both safety-related and non-safety related cooling loads. The Engineered Safety Features (ESF) SWS valve lineup isolates all non-safety related piping.

Trojan shuts down each year (during spring runoff as hydropower sources are at maximum capacity) for refueling and maintenance. Many plant modifications can only be performed during plant shutdown since safety-related systems are affected. During the 1991 refueling outage, one job modified safety-related room coolers served by the SWS. One aspect of the modifications was the replacement of throttle valves which control the distribution of limited service water flow to the coolers.

Part of the justification for system operability at power is to be provided by a test which balances the flow to the coolers. The system is to be placed in the ESF lineup and the cooler throttle valves are to be adjusted. The test will:

1. Adjust cooler flows so that each is at or above the required minimum flow for heat transfer requirements. These minimum flows are contained in the Final Safety Analysis Report (FSAR) and Design Basis Document (DBD) for the SWS.

2. Document the final flows and associated throttle valve positions.

3. Add the valve positions to the Locked Valve List in order to ensure that

the valves are not inadvertently repositioned during system operation.

Even during plant shutdown, one train of the SWS must be operable to serve certain loads. Thus, maintenance is performed on one train at a time during a "train outage." The flow balance test is performed at the end of the train outage and is expected to be on the critical path for plant restart. Since no permanent flowmeters are installed in the individual cooler lines, strap-on ultrasonic flowmeters are to be used in the test (two recorders are available, with several strap-on sensors each). The manipulation of valves will be an iterative process starting from a best estimate valve position. A good initial valve setting is essential to avoid multiple iterations and lost time.

Since the SWS uses Columbia River Water which is high in silt and impurities, certain lines are prone to flow degradation from silt buildup. These lines are flushed as necessary to maintain adequate flow. It is thus desirable to maintain flows as high as possible, both for heat transfer and flow considerations.

One area which requires frequent line flushing is a set of eight room coolers aligned in parallel. The system configuration can lead to low fluid velocity at the end of the line.

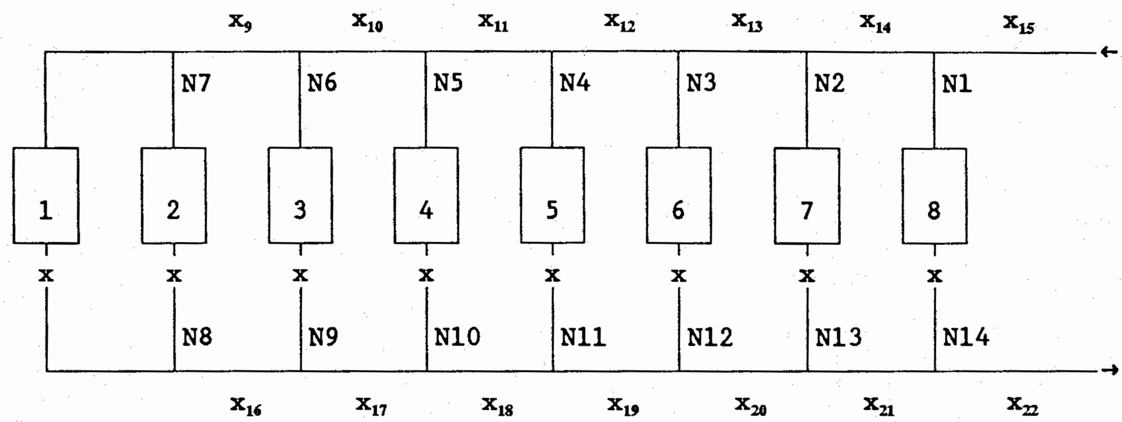
This project will use a linear approximation of this section of the system to determine the target flows for test personnel which maximize system flow and meet minimum flow requirements for system operability. Operating experience will be used to model the network flow interactions among the cooler lines.

3.0 Mathematical Model

The ESF portion of the SWS is highlighted in Figures 1a,b,c,d and further outlined in Figure 2. The coolers which are to be modeled are shown on this figure, and for simplicity will be renumbered as follows:

Cooler	Number	Cooler	Number
V-163B	1	V-143B	5
V-164	2	V-143D	6
VE-160B	3	V-145B	7
V-145D	4	V-143F	8

The network is modeled as follows:



The objective function is to maximize total flow

$$x_{15} = x_1 \quad x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8$$

where individual flows are designated x_i (including x_j for flow through cooler j). The Ns represent nodes which can be used in flow conservation equations:

Node	Flow Conservation Equation	
1	$x_{15} - x_8 - x_{14} = 0$	
2	$x_{14} - x_7 - x_{13} = 0$	
3	$x_{13} - x_6 - x_{12} = 0$	
4	$x_{12} - x_5 - x_{12} = 0$	
5	$x_{11} - x_4 - x_{10} = 0$	
6	$x_{10} - x_3 - x_9 = 0$	
7	$x_9 - x_2 - x_1 = 0$	
8	$x_{16} - x_2 - x_1 = 0$	$(x_{16} = x_9)$
9	$x_{17} - x_3 - x_{16} = 0$	$(x_{17} = x_{10})$
10	$x_{18} - x_4 - x_{17} = 0$	$(x_{18} = x_{11})$
11	$x_{19} - x_5 - x_{18} = 0$	$(x_{19} = x_{12})$
12	$x_{20} - x_6 - x_{19} = 0$	$(x_{20} = x_{13})$
13	$x_{21} - x_7 - x_{20} = 0$	$(x_{21} = x_{14})$
14	$x_{22} - x_8 - x_{21} = 0$	$(x_{22} = x_{15})$

Note that equations 8 through 14 are redundant with equations 1 through 7. Also, equations 1 through 7 may be added to give the following:

$$x_{15} = x_1 \quad x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8$$

Thus, all the flow conservation requirements are completely contained in the simple sum of flows through the coolers. Since this information is contained in the objective function, no constraint equations are necessary from the flow conservation requirements.

The following minimum flow constraints apply, based on Design Basis Document requirements (the flows are in units of gpm):

$x_1 \geq 29$
$x_2 \geq 29$
$x_3 \geq 30$
$x_4 \geq 30.4$
$x_5 \geq 18$
$x_6 \geq 18$
$x_7 \geq 30.4$
$x_8 \geq 18$

The most difficult part of modeling the network is to constrain flow interactions to realistic behavior. Operational experience is used to approximate this behavior at normal system operating conditions in the ESF lineup. The approach is to change the flow in one line and approximate the effect on all other lines. For instance, it is estimated that closing valve 8 will give approximately 35 gpm in line 1, all other valve settings remaining fixed. If valve 8 is then opened enough to decrease flow in line 1 by 1 gpm, the resultant flow in line 8 is approximately 0.20 gpm. This relationship is modeled as $x_1 + 0.20x_8 \leq 35$. As shown on Figure 3, changes to the variable coefficient change the slope of the constraint equation, and changes to the right hand side move the constraint equation inward or outward from the origin.

Modeling the flows in this way is an attempt to linearize the model in the region of interest (near historical flow values).

All interactions among flows are approximated in the same way, with the results summarized in Table 1. The resulting model is a maximization problem using 8 + 28 = 36 constraints.

Valve i	Valve j	Note 1	Note 2	Resulting constraint
8	1	35	0.20	$x_1 + 0.20x_8 \le 35$
	2	35	0.15	$x_2 + 0.15x_8 \le 35$
	3	35	0.10	$x_3 + 0.10x_8 \le 35$
	4	37	0.10	$x_4 + 0.10x_8 \le 37$
	5	25	0.05	$x_5 + 0.05x_8 \le 25$
	6	27	0.20	$x_6 + 0.20x_8 \le 27$
	7	43	0.30	$x_7 + 0.30x_8 \le 43$
7	1	41	0.30	$x_1 + 0.30x_7 \le 41$
	2	36	0.15	$x_2 + 0.15x_7 \le 36$
	3	38	0.15	$x_3 + 0.15x_7 \le 38$
	4	40	0.15	$x_4 + 0.15x_7 \le 40$
	5	28	0.15	$x_5 + 0.15x_7 \le 28$
	6	29	0.20	$x_6 + 0.20x_7 \le 29$
6	1	35	0.20	$x_1 + 0.20x_6 \le 35$
	2	35	0.20	$x_2 + 0.20x_6 \le 35$
	3	37	0.20	$x_3 + 0.20x_6 \le 37$
	4	39	0.20	$x_4 + 0.20x_6 \le 39$
	5	28	0.20	$x_5 + 0.20x_6 \le 28$
5	1	37	0.30	$x_1 + 0.30x_5 \le 37$
	2	38	0.25	$x_2 + 0.25x_5 \le 38$
	3	37	0.25	$x_3 + 0.25x_5 \le 37$
	4	37	0.30	$x_4 + 0.30x_5 \le 37$
4	1	42	0.35	$x_1 + 0.35x_4 \le 42$
	2	41	0.30	$x_2 + 0.30x_4 \le 41$
	3	41	0.25	$x_3 + 0.25x_4 \le 41$
3	1	45	0.45	$x_1 + 0.45x_3 \le 45$
	2	42	0.35	$x_2 + 0.35x_3 \le 42$
2	1	49	0.60	$x_1 + 0.60x_2 \le 49$

Note 1 Line j flow for valve i closed
Note 2 Line i flow increase for 1 gpm decrease in line j

Table 1. Maximum Flow Constraints

4.0 Results and Model Refinement

The model was entered into the LINDO computer program for analysis. The solution was as follows (see Appendix A for computer printouts):

Total flow = 228.4 gpm

Cooler	Model Flow [gpm]	DBD Minimum Flow [gpm]	Flow Margin [%]
1	29.0	29.0	0.0
2	30.5	29.0	5.2
3	31.5	30.0	5.0
4	30.4	30.4	0.0
5	22.0	18.0	22.2
6	21.0	18.0	16.7
7	34.0	30.4	11.8
8	30.0	18.0	66.7

Although these flows all meet the DBD minimum flow requirements, it is apparent that the upstream coolers have excessive flow margin at the expense of the downstream coolers. Coolers 1 and 4 are at the design minimum flow.

In order to provide some flow margin in coolers 1 and 4, some flow will need to be diverted from the other coolers. The overall flow will decrease as these changes are made. However, some decrease in overall flow is tolerable if the flow margins can be better balanced. Cooler 1 especially has had silting problems in the past and it is desirable to establish a reasonable flow margin in this line.

With this intent, the model was revised by including flow goals for coolers 1 and 4. Flow variables x_1 and x_4 were essentially replaced by $(x_1 + D_1)$ and $(x_4 + D_2)$ respectively, wherever they occurred in the maximum flow constraints. The variables D_1 and D_2 were added to the objective function with large coefficients (10^6). The minimum flow constraints for x_1 and x_4 were then revised to incorporate a goal of a 10% flow margin:

$$x_1 + D_1 \leq 1.1(29) = 31.9$$
$$x_4 + D_2 \leq 1.1(30.4) = 33.44$$

The results of this model are as follows (see Appendix B):

Total flow = 216.0 gpm

Cooler	Model Flow [gpm]	DBD Minimum Flow [gpm]	Flow Margin [%]
1	30.9	29.0	6.7

Cooler	Model Flow [gpm]	DBD Minimum Flow [gpm]	Flow Margin [%]
2	30.1	29.0	3.8
3	31.2	30.0	4.1
4	31.6	30.4	3.9
5	18.0	18.0	0.0
6	20.3	18.0	12.8
7	33.5	30.4	10.3
8	20.3	18.0	12.8

Although the goals of 10% margin for x_1 and x_4 have not been reached, some margins now exist (6.7%, 3.9%, respectively) and the flows have evened somewhat. The total flow has decreased by 12 gpm (≈ 5.4%). It is decided that this tradeoff is acceptable, but another concern has come up: the margin on x_5 has been driven to zero. This is deemed unacceptable.

The next adjustment to the model establishes a goal of 5% flow margin for x_5 as the top priority. This is accomplished by giving the new variable D_3 a coefficient of 10^7, an order of magnitude greater than the coefficients on D_1 and D_2. As before, x_5 is replaced by $(x_5 + D_3)$ in the maximum flow constraint equations, and the minimum flow constraint is changed to

$$x_5 + D_3 \leq 1.05(18) = 18.9$$

The other two goals are not changed. The results are as follows (see Appendix C):

Total flow = 215.1 gpm

Cooler	Model Flow [gpm]	DBD Minimum Flow [gpm]	Flow Margin [%]
1	31.0	29.0	7.0
2	29.9	29.0	3.3
3	31.0	30.0	3.4
4	31.3	30.4	3.1
5	18.9	18.0	5.0
6	19.8	18.0	10.2
7	33.2	30.4	9.3
8	19.8	18.0	10.2

In this case, goal 1 has been met (5% margin on cooler 5), and goals 2 and 3 have not been met (10% margins on coolers 1,4). An additional 1 gpm has been lost from overall flow (total reduction = 13 gpm, ≈ 5.8%). The lowest margins are approximately 3%, for coolers 2-4. This is a reasonable compromise, but an additional model refinement was made in an attempt to raise the lowest margin (3.1% on cooler 4). This was done by leaving goal 1 (5% on x_5) unchanged but making the goal for x_4 greater in priority than the goal for x_1.

The results were unchanged (see Appendix D).

Next, in a further attempt to raise x_4, the priorities for the three goals were revised:

Cooler	Goal [%]	Variable	Coefficient	Goal Rank
4	5	D_2	10^7	1
5	5	D_3	10^6	2
1	10	D_1	10^5	3

This model has the following solution (see Appendix E):

Total flow = 216.0 gpm

Cooler	Model Flow [gpm]	DBD Minimum Flow [gpm]	Flow Margin [%]
1	31.9	29.0	6.7
2	30.1	29.0	3.8
3	31.2	30.0	4.1
4	31.6	30.4	3.9
5	18.0	18.0	0.0
6	19.8	18.0	12.8
7	33.2	30.4	11.0
8	19.8	18.0	12.8

None of the three goals has been met, while the margin in cooler 5 has been driven to zero. This is exactly the solution calculated earlier (Appendix B), indicating that the goal re-ranking did not avoid the interconnected maximum flow constraints. The previous solution is preferable.

The flow balance of Appendix C was determined to be the best compromise, in that further flow increases to the coolers with 3% margin would only reduce overall flow and degrade the margins on the upstream coolers. Figure 4 shows the progression of model refinements. The individual flow margins and total flow are shown at each iteration. Note that the third row of flow margins (corresponding to 215 gpm) is the most balanced of the four cases.

5.0 Sensitivity Analysis

This linear model of network flow through room coolers in parallel does not lend itself to sensitivity analysis in the usual manner. The range on the right-hand side value of a single (maximum flow) constraint equation has little meaning since such a change would not correspond to a physical situation. Changing one right-hand value would require changes in other flow constraint equations to be consistent.

For instance, consider the effect of increasing the line size and thus flow capacity of line 1. This has an effect on all seven maximum flow constraint equations involving x_1. To evaluate such a change, all constraints would have to be adjusted.

Changing the right-hand values on the minimum flow constraints is not realistic since the minimum flow values were calculated from heat transfer requirements which would not change without extensive plant modifications (such as reducing room heating loads, altering the assumed maximum SWS temperature to below 75°F, adding alternate cooling, etc).

In order to see the effect of increasing line size, changes were made to the model of Appendix C. Since line 1 is among the most difficult to force flow through, the x_1 maximum flow constraints were relaxed to simulate increased line capacity and decreased flow resistance. A 10% increase was modeled:

Row #	Old Constraint	Revised Constraint
8	$x_1 + 0.20x_8 \le 35$	$x_1 + 0.220x_8 \le 38.5$
15	$x_1 + 0.30x_7 \le 41$	$x_1 + 0.330x_7 \le 45.1$
21	$x_1 + 0.20x_6 \le 35$	$x_1 + 0.220x_7 \le 38.5$
26	$x_1 + 0.30x_5 \le 37$	$x_1 + 0.330x_6 \le 40.7$
30	$x_1 + 0.35x_4 \le 42$	$x_1 + 0.385x_6 \le 46.2$
33	$x_1 + 0.45x_3 \le 45$	$x_1 + 0.495x_6 \le 49.5$
35	$x_1 + 0.60x_2 \le 49$	$x_1 + 0.660x_6 \le 53.9$

The results of this model are (see Appendix F):

Total flow = 229.6 gpm

Cooler	Model Flow [gpm]	DBD Minimum Flow [gpm]	Flow Margin [%]
1	31.9	29.0	10.0
2	30.5	29.0	5.2
3	32.0	30.0	6.7
4	31.3	30.4	3.1
5	18.9	18.0	5.0
6	21.0	18.0	16.7
7	34.0	30.4	11.8
8	30.0	18.0	66.7

In this case, goal 1 (5% margin on cooler 5) has been met. Sufficient capacity has been added to meet goal 2 also (10% margin on cooler 1). However, even with the excess flow present, not enough is available to meet goal 3 (10% margin on cooler 4). In fact, cooler 4 continues to have a margin below 5%. The overall flow has increased to over 229 gpm, approximately the maximum value for the original model. Most of this flow increase has again been directed to the upstream coolers (note the 12 gpm margin on cooler 8).

Thus, increasing the size of a single line helps flow through that line, but does not substantially assist other lines. More sweeping changes involving all lines (such as increased header size or larger pressure head at the inlet) are required if flow margins are to be increased in all lines.

6.0 Conclusions

The maximum overall flow through the coolers is approximately 228 gpm. In order to achieve this flow, coolers 1 and 4 are limited to the minimum flow allowable by the Service Water System Design Basis Document. Since it is desirable to maintain some margin above the minimum flow for all coolers, some compromise between overall flow and balanced flow between coolers is necessary. The recommended flows are those listed in Appendix C:

Total flow = 215.1 gpm

Cooler	Model Flow [gpm]	DBD Minimum Flow [gpm]	Flow Margin [%]
1	31.0	29.0	7.0
2	29.9	29.0	3.3

Cooler	Model Flow [gpm]	DBD Minimum Flow [gpm]	Flow Margin [%]
3	31.0	30.0	3.4
4	31.3	30.4	3.1
5	18.9	18.0	5.0
6	19.8	18.0	10.2
7	33.2	30.4	9.3
8	19.8	18.0	10.2

The overall flow is reduced by approximately 13 gpm (5.8%) with the lowest flow margins approximately 3% for coolers 2,3,4. This is deemed a reasonable compromise.

Coolers 1 and 4 are the most difficult to establish flow through. A change to the carrying capacity (line size) of one line does not significantly affect flow through other lines, except that any increase of this type tends to direct additional flow through the upstream coolers where flow resistance is smallest. In order to increase both total flow and all flow margins, changes to the system should affect the entire system. Increasing header size, increasing pressure differential across the coolers, or decreasing the required cooler flow through reductions in individual heat loads are examples of changes of this type. All of these changes involve considerable expense to accomplish.

6.0 Extensions

As shown on Figure 2, the ESF portion of the SWS has several legs which are fairly isolated from the other parts of the SWS. Specifically, the following systems are served:

1. Safety-related room coolers (three legs are present, each leg having several coolers)
2. Emergency Diesel Generator coolers
3. Auxiliary Feedwater System coolers
4. Component Cooling Water Heat Exchanger

Each of these legs is fairly independent of the other in terms of flow balancing. Changing the flow resistance of a room cooler line, for instance, affects other room coolers in that leg but does not appreciably alter flows in the Auxiliary Feedwater leg. In fact, decreasing flow through the Component

Cooling Water heat exchanger by 1000 gpm (DBD minimum flow = 13,750 gpm) adds only approximately 40 gpm to the suction line of the Service Water Booster Pumps (see Figure 2).

Thus, each leg could be modeled as was done for this project, and these models could be combined in an overall model where each major leg is considered an individual cooling load. However, such a model would require a considerable number of flow constraints. Each of these constraints would have a certain amount of inaccuracy since:

1. The constraints are linear approximations of non-linear flow behavior
2. The constraints are based on best available information, including operating experience

If a large flow network were constructed using such constraints, it is likely that overall accuracy would suffer.

7.0 References

1. Trojan Nuclear Plant Piping and Instrumentation Diagram M-218, Sheet 1, Revision 45, Service Water System
2. Trojan Nuclear Plant Piping and Instrumentation Diagram M-218, Sheet 2, Revision 10, Service Water System
3. Trojan Nuclear Plant Piping and Instrumentation Diagram M-462, Revision 3, Diesel Generator Cooling Water System
4. Trojan Nuclear Plant Piping and Instrumentation Diagram M-213, Sheet 4, Revision 13, Condensate and Feedwater System
5. Trojan Nuclear Plant Design Basis Document 11, Revision 1, Service Water System
6. Schrage, Linus, User's Manual for Linear, Integer, and Quadratic Programming With LINDO, Fourth Edition, The Scientific Press, San Francisco, CA, 1989

COLOR LEGEND

QUALITY GROUP 1

QUALITY GROUP 2

QUALITY GROUP 3A & 3B

QUALITY GROUP { 4A / 4B

NOTES:

1. FOR FLUID SYSTEM SYMBOLS AND LEGEND SEE FIGURE 1.7-1.
2. FOR QUALITY GROUP APPLICATION AND CODE CLASSIFICATION (FOR TROJAN PLANT) SEE TABLE 3.2-1.
3. INSTRUMENT CONNECTION ROOT VALVES ARE NOT SHOWN. CLASSIFICATION OF INSTRUMENT CONNECTION PIPING FROM PROCESS LINE UP TO ROOT VALVE IS SHOWN WHERE APPLICABLE BY SAME COLOR LEGEND.
4. FIGURE 10.4-2 B IS TAKEN FROM P&ID M-213 SHT.4 REV. 11.
5. BY CONVENTION SOME INSTRUMENT TIE LINES, SUCH AS THOSE FOR PRESSURE POINTS, ARE SHOWN AS BLACK. IN SOME CASES, A MINIMAL LENGTH OF TUBING OR SMALL PIPE, NOT DEPICTED ON THE P&ID, MAY EXIST. THIS CONVENTION IS NOT MEANT TO INFER THAT THIS TUBING OR PIPING IS QUALITY CATEGORY 4B. ANY TUBING OR PIPING BRANCHING OFF THE PROCESS PIPE MUST MEET THE QUALITY CATEGORY GUIDELINES AS DISCUSSED IN CHAPTER 3.

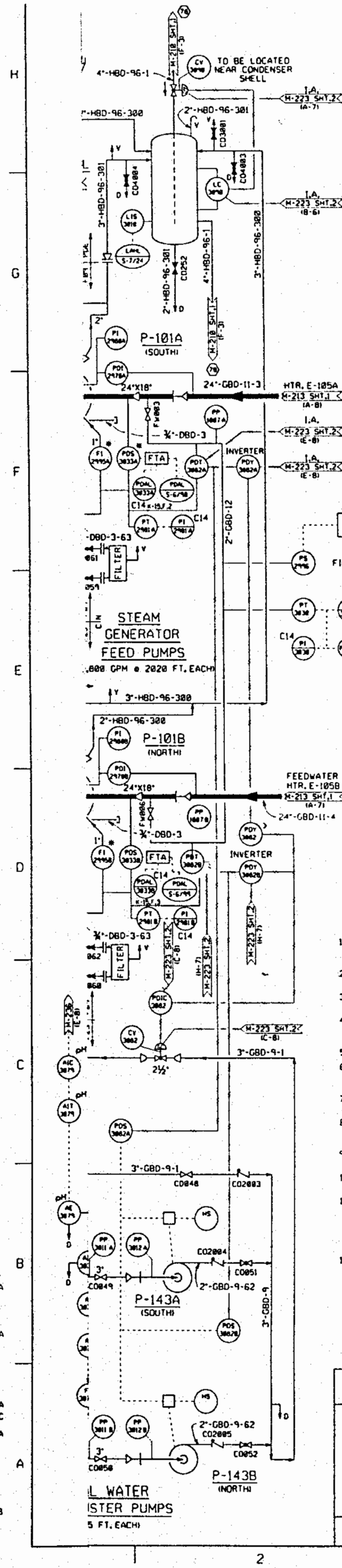


FIGURE 1d

NOTES:

1. ALL PIPING RUNS BETWEEN THE CONDENSER SHELLS DESIGNATED BY A ▩ SYMBOL SHALL BE INSTALLED BY THE F09 CONTRACTOR.
2. ENTIRE SYSTEM IS SEISMIC CATEGORY II EXCEPT AS NOTED.
3. AUTO-MANUAL STATION LIGHT ON MAIN CONTROL BOARD IS LIT WHEN IN MANUAL.
4. ALL DRAINS ON COND. PUMPS NOT PIPED BY BYRON-JACKSON SHALL BE PIPED TO THE CLEAN WASTE DRAINS.
5. DELETED
6. ALTERNATELY ALIGN F.W. TRAINS A & B TO SAMPLING SYSTEM TO ALLOW INDIVIDUAL SAMPLING OF F.W. TRAINS.
7. PIPE SPEC DOWNSTREAM OF ROOT VALVES FOR FE-3043A, B, C & D SHALL BE EBD-6.
8. C/S LOCATED MINIMUM 6' DOWNSTREAM OF DBD FLANGE. RECIRC. LINE SHOULD NOT BE USED WHEN S.G.F.P. IS OPERATING.
9. TO AUX. FEEDWATER PUMP TURBINE DRIVER DRAIN COOLERS.
10. VALVE MO3060A (COORD. A-5) AUTO START POWER DISCONNECTED PER RDC 78-020.
11. THE OPEN & CLOSE SEALING CONTACTS FOR CONDENSATE DEMINERALIZER BYPASS VALVES MO7100A & B (M-213 SHT. 1 COORD. A-5 & B-3) WERE DISCONNECTED PER RDC 81-030 TO PERMIT THROTTLING OF THE VALVES USING THE CONTROL ROOM HAND SWITCHES.
12. THE START-UP SUCTION STRAINER INTERNALS FOR PUMPS P-102A & B HAVE BEEN REMOVED. SPOOL PIECES FOR THESE STRAINERS REMAIN IN PLACE.

REFERENCE DRAWING	P&ID NO.	FIG. NO.
1. MAIN STEAM SYSTEM SHEET 1	M-208 SHT.1	10.2-3 A
2. MAIN STEAM SYSTEM SHEET 3	M-209	10.2-4
3. HEATER & MISC. DRAINS SYSTEMS SHEET 1	M-210 SHT.1	10.4-5 A
4. HEATER & MISC. DRAINS SYSTEMS SHEET 3	M-211	10.4-6
5. HEATER & MISC. VENTS SYSTEMS	M-212	10.4-4
6. CONDENSATE & FEEDWATER SYSTEM	M-213 SHT.1 M-213 SHT.2	10.4-2 A 10.4-2 C
7. AUXILIARY STEAM SYSTEMS	M-214 SHT.1	10.4-3 A
8. SERVICE WATER SYSTEM	M-218 SHT.1	9.2-1 A
9. INSTRUMENT & SERVICE AIR SYSTEM	M-223 SHT.2	9.3-1 B
10. MAKE-UP WATER TREATMENT SYSTEM	M-228 SHT.2	9.2-8 B
11. PROCESS SAMPLING SYSTEM	M-231 SHT.2	9.3-3
12. CONDENSATE AND FEEDWATER CHEMICAL INJECTION SYSTEM	M-236	10.4-10

Amendment 15
(December 1990)

TROJAN NUCLEAR PLANT
F.S.A.R.

CONDENSATE & FEEDWATER SYSTEM

FIGURE 10.4-2 B

COLOR LEGEND

QUALITY GROUP 1

QUALITY GROUP 2

QUALITY GROUP 3A & 3B

QUALITY GROUP { 4A / 4B

NOTES:

1. FOR FLUID SYSTEM SYMBOLS AND LEGEND SEE FIGURE 1.7-1.
2. FOR QUALITY GROUP APPLICATION AND CODE CLASSIFICATION (FOR TROJAN PLANT) SEE TABLE 3.2-3.
3. INSTRUMENT CONNECTION ROOT VALVES ARE NOT SHOWN. CLASSIFICATION OF INSTRUMENT CONNECTION PIPING FROM PROCESS LINE UP TO ROOT VALVE IS SHOWN WHERE APPLICABLE BY SAME COLOR LEGEND.
4. FIGURE 9.5-8 IS TAKEN FROM P&ID M-462 REV. 1.
5. BY CONVENTION SOME INSTRUMENT TIE LINES, SUCH AS THOSE FOR PRESSURE POINTS, ARE SHOWN AS BLACK. IN SOME CASES, A MINIMAL LENGTH OF TUBING OR SMALL PIPE, NOT DEPICTED ON THE P&ID, MAY EXIST. THIS CONVENTION IS NOT MEANT TO INFER THAT THIS TUBING OR PIPING IS QUALITY CATEGORY 4B. ANY TUBING OR PIPING BRANCHING OFF THE PROCESS PIPE MUST MEET THE QUALITY CATEGORY GUIDELINES AS DISCUSSED IN CHAPTER 3.

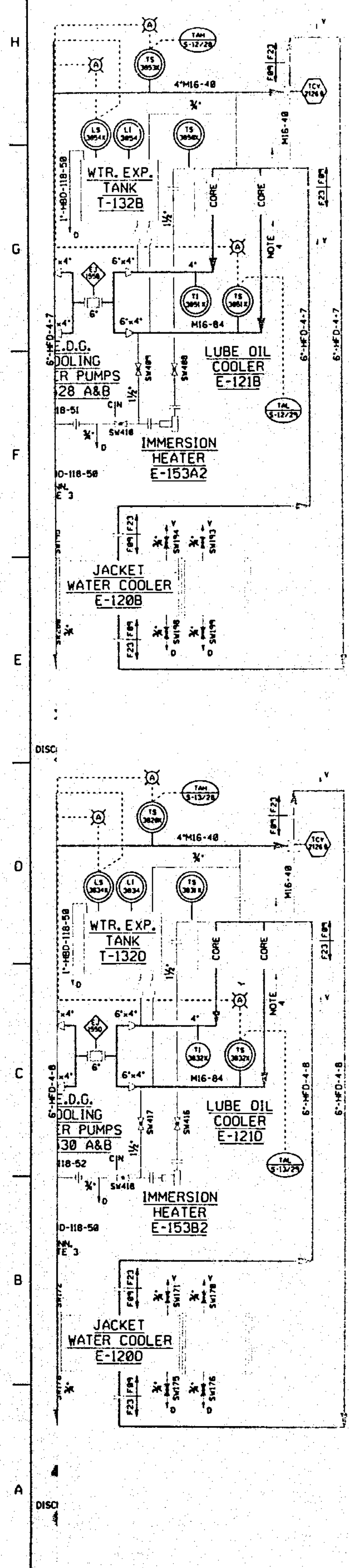


FIGURE 1c

NOTES:

1. ENTIRE SYSTEM IS SEISMIC CATEGORY I U.N.O.
2. BUTTERFLY VALVES ON DISCHARGE OF DIESEL GENERATOR JACKET WATER COOLERS AND GLOBE VALVES ON COMBUSTION AIR COOLERS TO BE SET FOR OPERATION AND LOCKED IN POSITION.
3. CONNECTION FOR DIESEL FILL SEE DRAWING HBD-118-50.
4. FOR LUBE OIL SEE M-461.

REFERENCE DRAWING	P&ID NO.	FIG. NO.
1. CIRCULATING WATER & TURBINE BUILDING COOLING WATER SYSTEM	M-216 SHT. 1	10.4-1 A
2. SERVICE WATER SYSTEM	M-218 SHT. 1	9.2-1 A

Amendment 14
(October 1990)

TROJAN NUCLEAR PLANT
F.S.A.R.

DIESEL GENERATOR
COOLING WATER SYSTEM

FIGURE 9.5-8

COLOR LEGEND

QUALITY GROUP 1
QUALITY GROUP 2
QUALITY GROUP 3A & 3B
QUALITY GROUP {4A, 4B}

NOTES:

1. FOR FLUID SYSTEM SYMBOLS AND LEGEND SEE FIGURE 1.7-1.
2. FOR QUALITY GROUP APPLICATION AND CODE CLASSIFICATION (FOR TROJAN PLANT) SEE TABLE 3.2-3.
3. INSTRUMENT CONNECTION ROOT VALVES ARE NOT SHOWN. CLASSIFICATION OF INSTRUMENT CONNECTION PIPING FROM PROCESS LINE UP TO ROOT VALVE IS SHOWN WHERE APPLICABLE BY SAME COLOR LEGEND.
4. FIGURE 9.2-1 B IS TAKEN FROM P&ID M-218 SHT. 2, REV. 9.
5. BY CONVENTION SOME INSTRUMENT TIE LINES, SUCH AS THOSE FOR PRESSURE POINTS, ARE SHOWN AS BLACK. IN SOME CASES, A MINIMAL LENGTH OF TUBING OR SMALL PIPE, NOT DEPICTED ON THE P&ID, MAY EXIST. THIS CONVENTION IS NOT MEANT TO INFER THAT THIS TUBING OR PIPING IS QUALITY CATEGORY 4B. ANY TUBING OR PIPING BRANCHING OFF THE PROCESS PIPE MUST MEET THE QUALITY CATEGORY GUIDELINES AS DISCUSSED IN CHAPTER 3.

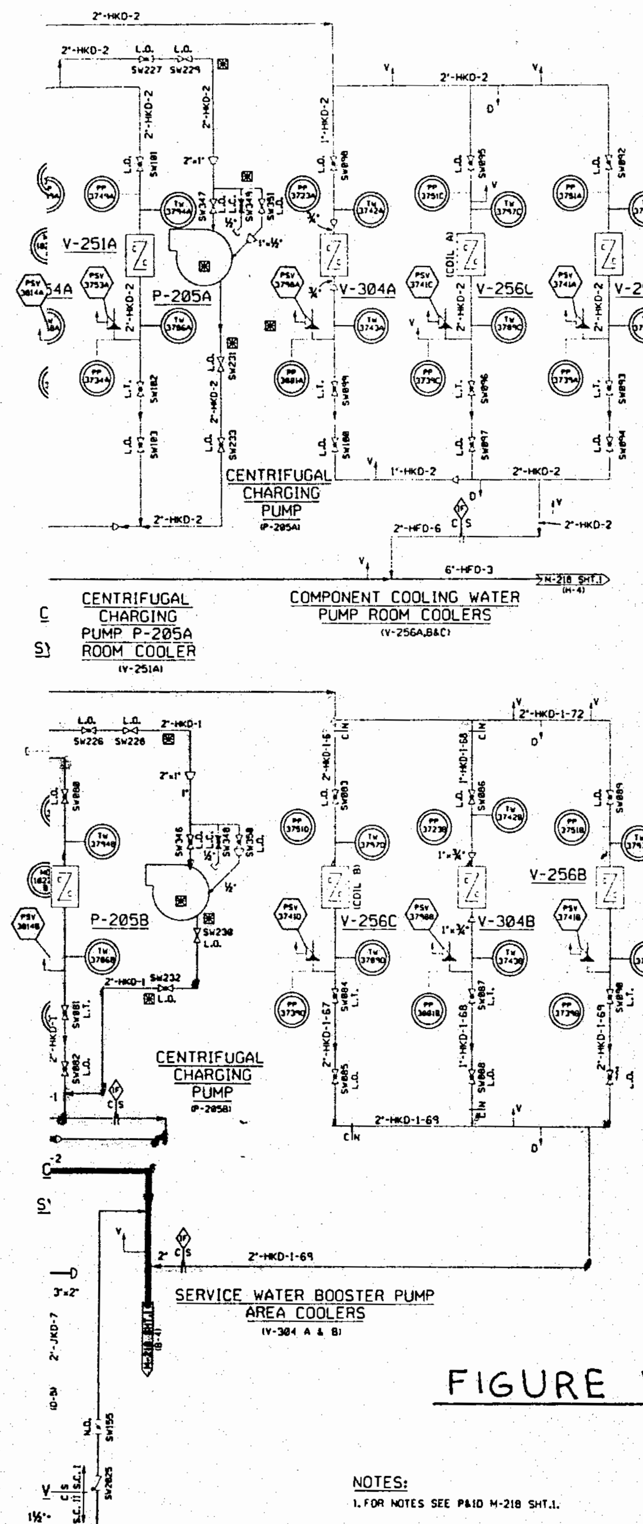


FIGURE 1b

REFERENCE DRAWING	P&ID NO.	FIG. NO.
1. SERVICE WATER SYSTEM	M-218 SHT.1	9.2-1 A
2. CLEAN RADIOACTIVE WASTE TREATMENT SYSTEM	M-220	11.2-9
3. RADIOACTIVE GASEOUS WASTE SYSTEM	M-222	11.3-4
4. PROCESS SAMPLING SYSTEM	M-231 SHT.2	9.3-3
5. PROCESS STEAM SYSTEM	M-237	10.4-9
6. CHILLED WATER SYSTEM	M-248 SHT.1 M-248 SHT.2	9.4-2 A 9.4-2 B
7. STEAM GENERATOR BLOWDOWN SYSTEM	M-348	10.4-8

NOTES:

1. FOR NOTES SEE P&ID M-218 SHT.1.

Amendment 14
(October 1990)

TROJAN NUCLEAR PLANT
F.S.A.R.

SERVICE WATER SYSTEM

FIGURE 9.2-1 B

COLOR LEGEND

QUALITY GROUP I

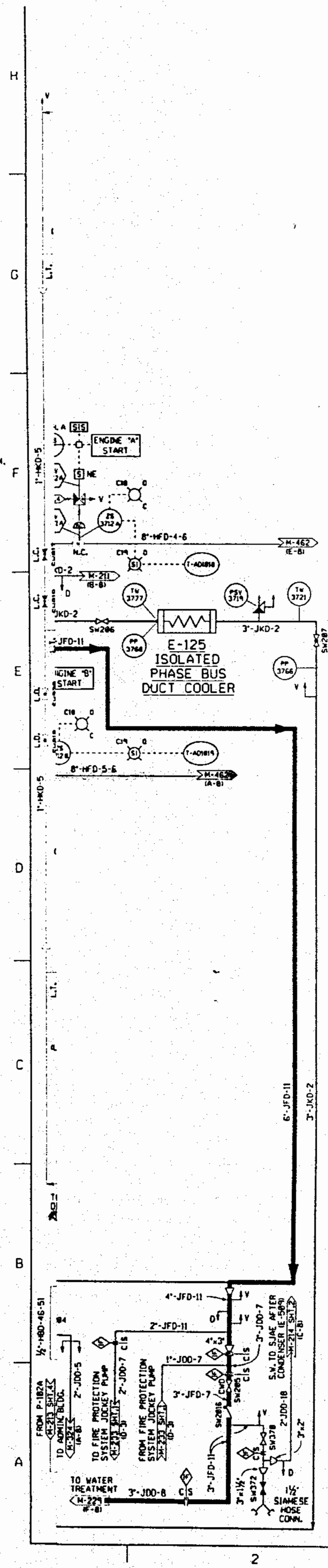
QUALITY GROUP 2

QUALITY GROUP 3A & 3B

QUALITY GROUP {4A / 4B}

NOTES:

1. FOR FLUID SYSTEM SYMBOLS AND LEGEND SEE FIGURE 1.7-1.
2. FOR QUALITY GROUP APPLICATION AND CODE CLASSIFICATION (FOR TROJAN PLANT) SEE TABLE 3.2-3.
3. INSTRUMENT CONNECTION ROOT VALVES ARE NOT SHOWN. CLASSIFICATION OF INSTRUMENT CONNECTION PIPING FROM PROCESS LINE UP TO ROOT VALVE IS SHOWN WHERE APPLICABLE BY SAME COLOR LEGEND.
4. FIGURE 9.2-1 A IS TAKEN FROM P&ID M-218 SHT. 1, REV. 44.
5. BY CONVENTION SOME INSTRUMENT TIE LINES, SUCH AS THOSE FOR PRESSURE POINTS, ARE SHOWN AS BLACK. IN SOME CASES, A MINIMAL LENGTH OF TUBING OR SMALL PIPE, NOT DEPICTED ON THE P&ID, MAY EXIST. THIS CONVENTION IS NOT MEANT TO INFER THAT THIS TUBING OR PIPING IS QUALITY CATEGORY 4B. ANY TUBING OR PIPING BRANCHING OFF THE PROCESS PIPE MUST MEET THE QUALITY CATEGORY GUIDELINES AS DISCUSSED IN CHAPTER 3.



REFERENCE DRAWING	P&ID NO.	FIG. NO.
1. HEATER & MISCELLANEOUS DRAINS SHEET 2	M-211	10.4-6
2. CONDENSATE & FEEDWATER SYSTEMS	M-213 SHT.4	10.4-2 B
3. AUXILIARY STEAM SYSTEM	M-214 SHT.2	10.4-3 B
4. COMPONENT COOLING WATER SYSTEM	M-215 SHT.1	9.2-4 A
5. CIRCULATING WATER & TURBINE BLDG. COOLING WATER SYSTEM	M-216 SHT.1 M-216 SHT.2	10.4-1 A 10.4-1 B
6. SERVICE WATER SYSTEM	M-218 SHT.2	9.2-1 B
7. BEARING COOLING WATER SYSTEM	M-219	9.2-6
8. INSTRUMENT AND SERVICE AIR SYSTEM	M-223 SHT.4 M-223 SHT.6	9.3-1 D 9.3-1 F
9. SPENT FUEL POOL COOLING & DEMINERALIZER SYSTEM	M-227	9.1-4
10. DOMESTIC WATER SYSTEM	M-229 SHT.1	9.2-7 A
11. INTAKE STRUCTURE & SCREEN WASH SYSTEM	M-230	9.2-2
12. FIRE PROTECTION SYSTEM	M-233 SHT.1	9.5-1
13. CHILLED WATER SYSTEM	M-359	9.4-15
14. EMERGENCY DIESEL GENERATOR COOLING WATER SYSTEM	M-462	9.4-8

NOTES:

1. ENTIRE SYSTEM IS SEISMIC CATEGORY I EXCEPT AS NOTED.
2. DELETED
3. LS-3752 A&B CAUSE SHUTDOWN OF SERVICE WATER PUMPS FOR PREVENTION OF FLOODING AT ELEV. 45 IN THE AUX. BUILDING IN THE EVENT OF A FAILURE IN SERVICE WATER SYSTEM PIPING. WATER ON THE FLOOR AT ELEV. 45 ACTUATES THE SWITCHES.
4. COOLER & CHILLER 1" PSV DISCHARGE & 2" BED PLATE DRAINS TO BE JBD-31. CHANGE SPEC. AT PSV DISCH. CONN. CHANGE FROM SEISMIC CAT. I TO CAT. II AT OUTLET OF PSV OR BED PLATE EXCEPT VE-160A & B BED PLATE DRAINS WHICH ARE SEISMIC CATEGORY I.
5. ROOM COOLER WASHDOWN CONNECTION PIPE SPEC. SHALL BE SAME AS PIPE TAPPED.
6. DELETED
7. DISSIMILAR METAL CONNECTIONS (S.S. OR C.S. TO CU-NI) BETWEEN COOLING COILS OR PSV'S AND ASSOCIATED PIPING SHALL HAVE I.F. KITS.
8. INDICATORS (COORDS. G-6, C-6, G-5, F-5, D-5 & C-5) ARE SC II. THE INSTRUMENT ROOT VALVES SHOULD BE NORMALLY CLOSED UNLESS SPECIFICALLY AUTHORIZED TO BE OPEN. INSTRUMENT ROOT VALVES FOR FI3816 AND FI3817 (COORDS. G-6, C-6) HAVE BEEN EVALUATED PER CALCULATION TM-183 AND MAY BE LEFT OPEN.
9. FOR COMPONENT COOLING WATER PIPING SEE P&ID M-215 SHT. 1; E-204A (F-4) & E-204B (C-4).
10. FOR BEARING COOLING WATER PIPING SEE P&ID M-219; E-130A (G-2) & E-130B (F-2).
11. SEGMENT OF LINE MATERIAL FOR LINE 8"-JFD-11 (COORD. A-4) IS A SPEC. EXCEPTION (SPEC. GCD MATERIAL USED) SEE RELATED ISOMETRIC.

FIGURE 1a

Amendment 13
(April 1990)

TROJAN NUCLEAR PLANT
F.S.A.R.

SERVICE WATER SYSTEM

FIGURE 9.2-1 A

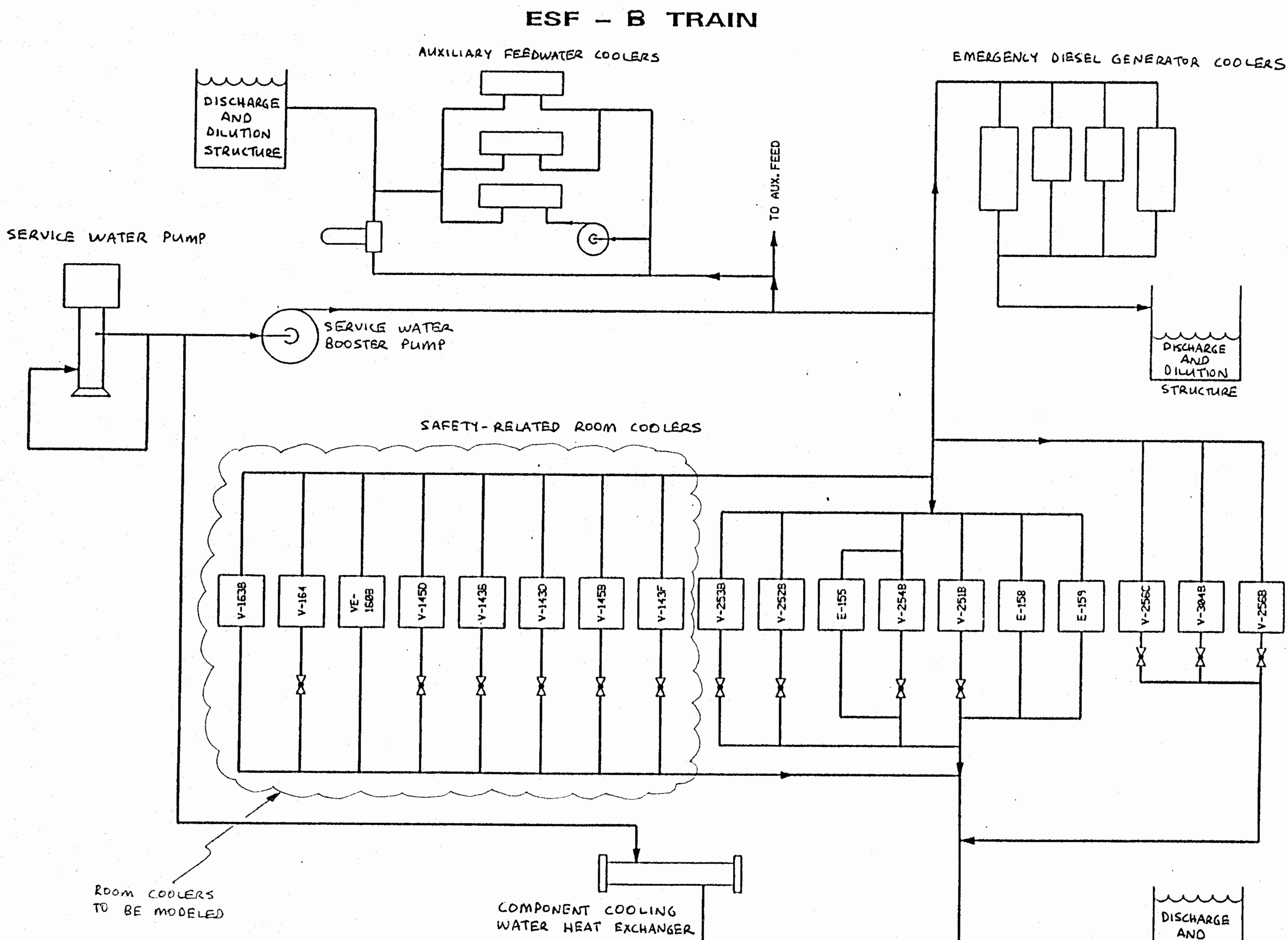

ESF – B TRAIN
AUXILIARY FEEDWATER COOLERS
EMERGENCY DIESEL GENERATOR COOLERS
DISCHARGE AND DILUTION STRUCTURE
TO AUX. FEED
SERVICE WATER PUMP
SERVICE WATER BOOSTER PUMP
DISCHARGE AND DILUTION STRUCTURE
SAFETY-RELATED ROOM COOLERS
V-163B
V-164
VE-160B
V-145D
V-143B
V-143C
V-145B
V-143F
V-253B
V-252B
E-155
V-254B
V-251B
E-158
E-159
V-256C
V-304B
V-256B
ROOM COOLERS TO BE MODELED
COMPONENT COOLING WATER HEAT EXCHANGER
DISCHARGE AND DILUTION STRUCTURE

FIGURE 2

Figure 3. Modeling Flow Upper Bound Constraints

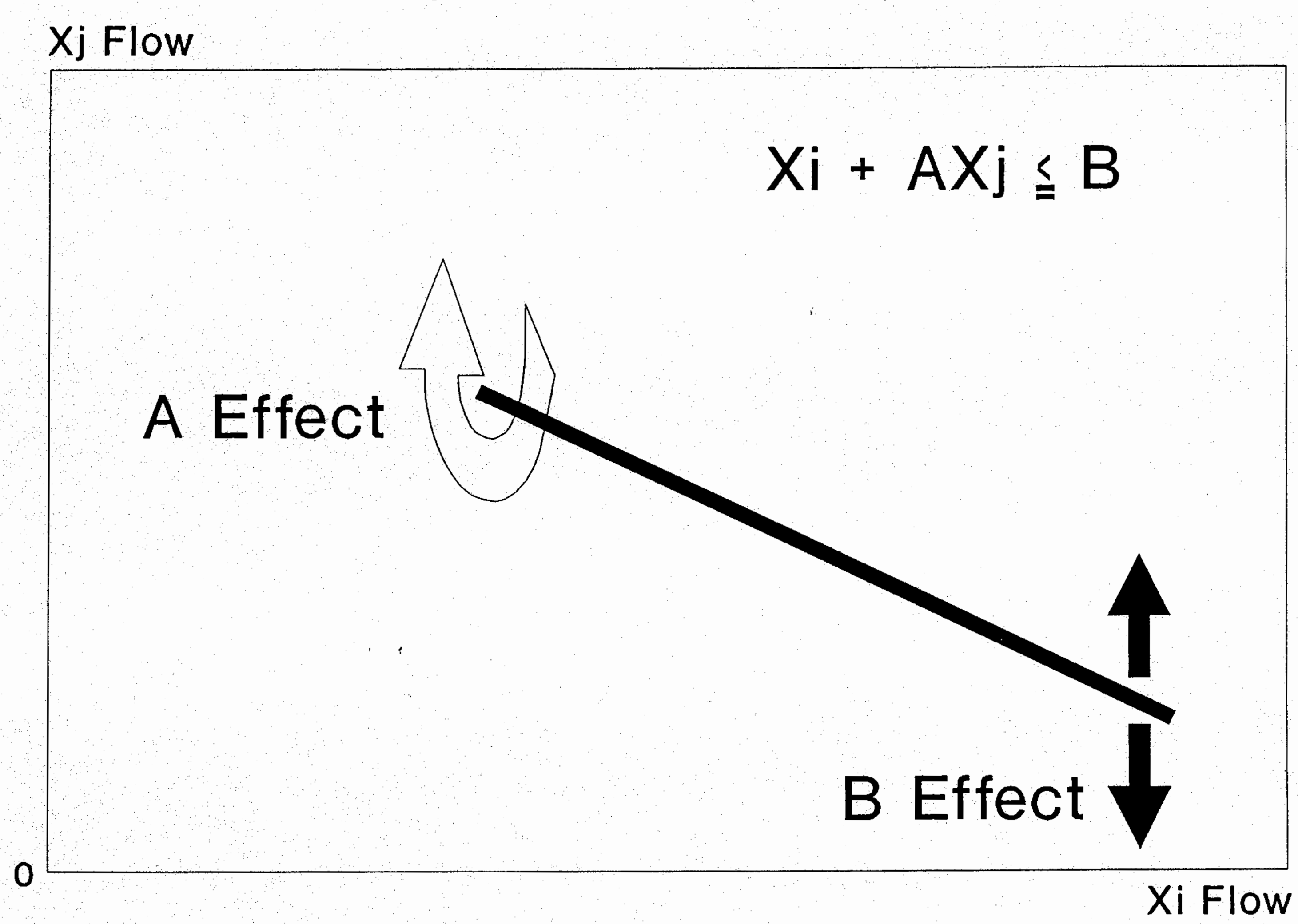
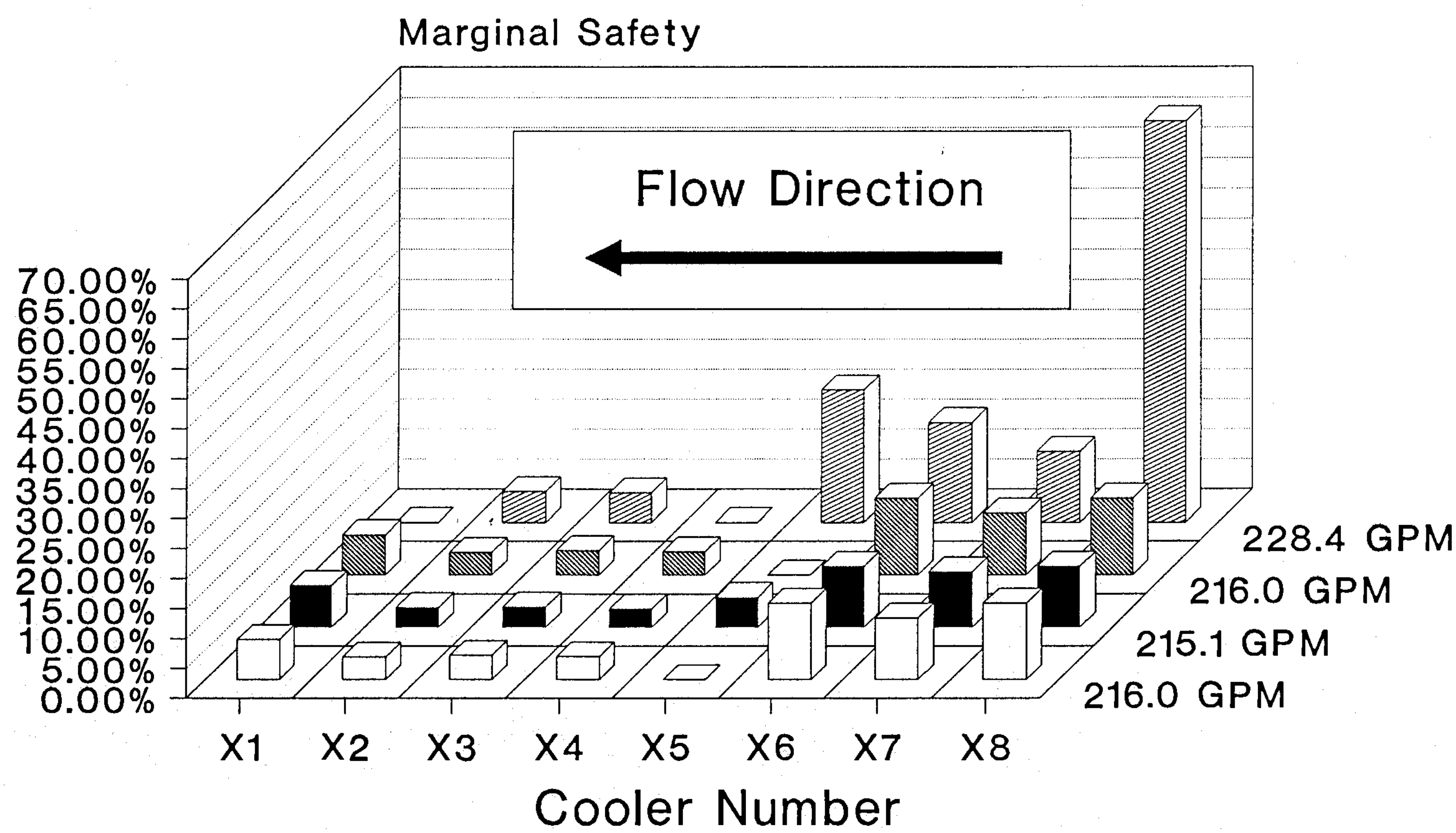


Fig. 4 Marginal Safety Per Cooler vs. Optimal Flow



```
MAX      X1 + X2 + X3 + X4 + X5 + X6 + X7 + X8

SUBJECT TO
       2)    X1 >=   29
       3)    X2 >=   29
       4)    X3 >=   30
       5)    X4 >=   30.4
       6)    X5 >=   18
       7)    X6 >=   18
       8)    X7 >=   30.4
       9)    X8 >=   18
      10)    X1 + 0.2 X8 <=   35
      11)    X2 + 0.15 X8 <=   35
      12)    X3 + 0.1 X8 <=   35
      13)    X4 + 0.1 X8 <=   37
      14)    X5 + 0.05 X8 <=   25
      15)    X6 + 0.2 X8 <=   27
      16)    X7 + 0.3 X8 <=   43
      17)    X1 + 0.3 X7 <=   41
      18)    X2 + 0.15 X7 <=   36
      19)    X3 + 0.15 X7 <=   38
      20)    X4 + 0.15 X7 <=   40
      21)    X5 + 0.15 X7 <=   28
      22)    X6 + 0.2 X7 <=   29
      23)    X1 + 0.2 X6 <=   35
      24)    X2 + 0.2 X6 <=   35
      25)    X3 + 0.2 X6 <=   37
      26)    X4 + 0.2 X6 <=   39
      27)    X5 + 0.2 X6 <=   28
      28)    X1 + 0.3 X5 <=   37
      29)    X2 + 0.25 X5 <=   38
      30)    X3 + 0.25 X5 <=   37
      31)    X4 + 0.3 X5 <=   37
      32)    X1 + 0.35 X4 <=   42
      33)    X2 + 0.3 X4 <=   41
      34)    X3 + 0.25 X4 <=   41
      35)    X1 + 0.45 X3 <=   45
      36)    X2 + 0.35 X3 <=   42
      37)    X1 + 0.6 X2 <=   49
```

LP OPTIMUM FOUND AT STEP 14
OBJECTIVE FUNCTION VALUE 1) 228.400000

VARIABLE	VALUE	REDUCED COST
X1	29.000000	.000000
X2	30.500000	.000000
X3	31.500000	.000000
X4	30.400000	.000000
X5	22.000000	.000000
X6	21.000000	.000000
X7	34.000000	.000000
X8	30.000000	.000000

ROW	SLACK OR SURPLUS	DUAL PRICES
2)	.000000	-.750000
3)	1.500000	.000000
4)	1.500000	.000000
5)	.000000	-1.500000
6)	4.000000	.000000
7)	3.000000	.000000
8)	3.600000	.000000
9)	12.000000	.000000
10)	.000000	1.750000
11)	.000000	1.000000
12)	.500000	.000000
13)	3.600000	.000000
14)	1.500000	.000000
15)	.000000	1.000000
16)	.000000	1.000000
17)	1.800000	.000000
18)	.400000	.000000
19)	1.400000	.000000
20)	4.500000	.000000
21)	.899999	.000000
22)	1.200000	.000000
23)	1.800000	.000000
24)	.300000	.000000
25)	1.300000	.000000
26)	4.400000	.000000
27)	1.800000	.000000
28)	1.400000	.000000
29)	2.000000	.000000
30)	.000000	1.000000
31)	.000000	2.500000
32)	2.360000	.000000
33)	1.380000	.000000
34)	1.900000	.000000
35)	1.825000	.000000
36)	.475000	.000000
37)	1.699999	.000000

NO. ITERATIONS= 14

RANGES IN WHICH THE BASIS IS UNCHANGED:

OBJ COEFFICIENT RANGES

VARIABLE	CURRENT COEF	ALLOWABLE INCREASE	ALLOWABLE DECREASE
X1	1.000000	.750000	INFINITY
X2	1.000000	1.000000	1.000000
X3	1.000000	1.800000	1.000000
X4	1.000000	1.500000	INFINITY
X5	1.000000	INFINITY	.450000
X6	1.000000	.750000	1.000000
X7	1.000000	.500000	1.000000
X8	1.000000	INFINITY	.150000

RIGHTHAND SIDE RANGES

ROW	CURRENT RHS	ALLOWABLE INCREASE	ALLOWABLE DECREASE
2	29.000000	.315789	1.000000
3	29.000000	1.500000	INFINITY
4	30.000000	1.500000	INFINITY
5	30.400000	.600000	.270000
6	18.000000	4.000000	INFINITY
7	18.000000	3.000000	INFINITY
8	30.400000	3.600000	INFINITY
9	18.000000	12.000000	INFINITY
10	35.000000	1.000000	.315789
11	35.000000	.300000	1.500000
12	35.000000	INFINITY	.500000
13	37.000000	INFINITY	3.600000
14	25.000000	INFINITY	1.500000
15	27.000000	1.200000	3.000000
16	43.000000	2.666666	3.600000
17	41.000000	INFINITY	1.800000
18	36.000000	INFINITY	.400000
19	38.000000	INFINITY	1.400000
20	40.000000	INFINITY	4.500000
21	28.000000	INFINITY	.899999
22	29.000000	INFINITY	1.200000
23	35.000000	INFINITY	1.800000
24	35.000000	INFINITY	.300000
25	37.000000	INFINITY	1.300000
26	39.000000	INFINITY	4.400000
27	28.000000	INFINITY	1.800000
28	37.000000	INFINITY	1.400000
29	38.000000	INFINITY	2.000000
30	37.000000	.500000	1.500000
31	37.000000	.270000	.600000
32	42.000000	INFINITY	2.360000
33	41.000000	INFINITY	1.380000
34	41.000000	INFINITY	1.900000
35	45.000000	INFINITY	1.825000
36	42.000000	INFINITY	.475000
37	49.000000	INFINITY	1.699999

```
MAX      X1 + X2 + X3 + X4 + X5 + X6 + X7 + X8 + 1000000 D1 + 1000000 D2

SUBJECT TO
        2)   X2 >=   29
        3)   X3 >=   30
        4)   X5 >=   18
        5)   X6 >=   18
        6)   X7 >=   30.4
        7)   X8 >=   18
        8)   X1 + 0.2 X8 + D1 <=   35
        9)   X2 + 0.15 X8 <=   35
       10)   X3 + 0.1 X8 <=   35
       11)   X4 + 0.1 X8 + D2 <=   37
       12)   X5 + 0.05 X8 <=   25
       13)   X6 + 0.2 X8 <=   27
       14)   X7 + 0.3 X8 <=   43
       15)   X1 + 0.3 X7 + D1 <=   41
       16)   X2 + 0.15 X7 <=   36
       17)   X3 + 0.15 X7 <=   38
       18)   X4 + 0.15 X7 + D2 <=   40
       19)   X5 + 0.15 X7 <=   28
       20)   X6 + 0.2 X7 <=   29
       21)   X1 + 0.2 X6 + D1 <=   35
       22)   X2 + 0.2 X6 <=   35
       23)   X3 + 0.2 X6 <=   37
       24)   X4 + 0.2 X6 + D2 <=   39
       25)   X5 + 0.2 X6 <=   28
       26)   X1 + 0.3 X5 + D1 <=   37
       27)   X2 + 0.25 X5 <=   38
       28)   X3 + 0.25 X5 <=   37
       29)   X4 + 0.3 X5 + D2 <=   37
       30)   X1 + 0.35 X4 + D1 + 0.35 D2 <=   42
       31)   X2 + 0.3 X4 + 0.3 D2 <=   41
       32)   X3 + 0.25 X4 + 0.25 D2 <=   41
       33)   X1 + 0.45 X3 + D1 <=   45
       34)   X2 + 0.35 X3 <=   42
       35)   X1 + 0.6 X2 + D1 <=   49
       36)   X1 >=   29
       37)   X4 >=   30.4
       38)   X1 + D1 <=   31.9
       39)   X4 + D2 <=   33.44
```

LP OPTIMUM FOUND AT STEP 15

OBJECTIVE FUNCTION VALUE 1) 3140213.00

VARIABLE	VALUE	REDUCED COST
X1	29.000000	.000000
X2	30.100000	.000000
X3	31.244440	.000000
X4	30.400000	.000000
X5	18.000000	.000000
X6	20.300000	.000000
X7	33.533330	.000000
X8	20.300000	.000000
D1	1.940000	.000000
D2	1.200000	.000000

ROW	SLACK OR SURPLUS	DUAL PRICES
2)	1.099998	.000000
3)	1.244445	.000000
4)	.000000	-195000.800000
5)	2.299998	.000000
6)	3.133332	.000000
7)	2.299998	.000000
8)	.000000	5.000000
9)	1.855002	.000000
10)	1.725555	.000000
11)	3.370000	.000000
12)	5.985000	.000000
13)	2.640002	.000000
14)	3.376669	.000000
15)	.000000	3.333333
16)	.870002	.000000
17)	1.725555	.000000
18)	3.370000	.000000
19)	4.970000	.000000
20)	1.993335	.000000
21)	.000000	5.000000
22)	.840002	.000000
23)	1.695556	.000000
24)	3.340000	.000000
25)	5.940000	.000000
26)	.660000	.000000
27)	3.400002	.000000
28)	1.255555	.000000
29)	.000000	650006.000000
30)	.000000	999982.800000
31)	1.420001	.000000
32)	1.855555	.000000
33)	.000000	2.222222
34)	.964446	.000000
35)	.000000	1.666667
36)	.000000	-999999.000000
37)	.000000	-999999.000000
38)	.959999	.000000
39)	1.839999	.000000

NO. ITERATIONS= 15

RANGES IN WHICH THE BASIS IS UNCHANGED:

		OBJ COEFFICIENT RANGES	
VARIABLE	CURRENT COEF	ALLOWABLE INCREASE	ALLOWABLE DECREASE
X1	1.000000	999999.000000	INFINITY
X2	1.000000	599989.700000	1.000000
X3	1.000000	449992.200000	1.000000
X4	1.000000	999999.000000	INFINITY
X5	1.000000	195000.800000	INFINITY
X6	1.000000	199996.500000	1.000000
X7	1.000000	299994.800000	1.000000
X8	1.000000	199996.500000	1.000000
D1	1000000.000000	1857151.000000	999982.800000
D2	1000000.000000	INFINITY	650002.700000

RIGHTHAND SIDE RANGES

ROW	CURRENT RHS	ALLOWABLE INCREASE	ALLOWABLE DECREASE
2	29.000000	1.099998	INFINITY
3	30.000000	1.244445	INFINITY
4	18.000000	1.629629	3.000007
5	18.000000	2.299998	INFINITY
6	30.400000	3.133332	INFINITY
7	18.000000	2.299998	INFINITY
8	35.000000	2.251113	.460000
9	35.000000	INFINITY	1.855002
10	35.000000	INFINITY	1.725555
11	37.000000	INFINITY	3.370000
12	25.000000	INFINITY	5.985000
13	27.000000	INFINITY	2.640002
14	43.000000	INFINITY	3.376669
15	41.000000	1.013001	.939999
16	36.000000	INFINITY	.870002
17	38.000000	INFINITY	1.725555
18	40.000000	INFINITY	3.370000
19	28.000000	INFINITY	4.970000
20	29.000000	INFINITY	1.993335
21	35.000000	.398667	.460000
22	35.000000	INFINITY	.840002
23	37.000000	INFINITY	1.695556
24	39.000000	INFINITY	3.340000
25	28.000000	INFINITY	5.940000
26	37.000000	INFINITY	.660000
27	38.000000	INFINITY	3.400002
28	37.000000	INFINITY	1.255555
29	37.000000	.900002	1.200000
30	42.000000	.460000	.315001
31	41.000000	INFINITY	1.420001
32	41.000000	INFINITY	1.855555
33	45.000000	.565000	.560000
34	42.000000	INFINITY	.964446
35	49.000000	.504001	.659999
36	29.000000	1.940000	29.000000
37	30.400000	1.200000	30.400000
38	31.900000	INFINITY	.959999
39	33.440000	INFINITY	1.839999

```
MAX     X1 + X2 + X3 + X4 + X5 + X6 + X7 + X8 + 1000000 D1 + 1000000 D2
     + 10000000 D3

SUBJECT TO
        2)   X2 >=   29
        3)   X3 >=   30
        4)   X5 >=   18
        5)   X6 >=   18
        6)   X7 >=   30.4
        7)   X8 >=   18
        8)   X1 + 0.2 X8 + D1 <=   35
        9)   X2 + 0.15 X8 <=   35
       10)   X3 + 0.1 X8 <=   35
       11)   X4 + 0.1 X8 + D2 <=   37
       12)   X5 + 0.05 X8 + D3 <=   25
       13)   X6 + 0.2 X8 <=   27
       14)   X7 + 0.3 X8 <=   43
       15)   X1 + 0.3 X7 + D1 <=   41
       16)   X2 + 0.15 X7 <=   36
       17)   X3 + 0.15 X7 <=   38
       18)   X4 + 0.15 X7 + D2 <=   40
       19)   X5 + 0.15 X7 + D3 <=   28
       20)   X6 + 0.2 X7 <=   29
       21)   X1 + 0.2 X6 + D1 <=   35
       22)   X2 + 0.2 X6 <=   35
       23)   X3 + 0.2 X6 <=   37
       24)   X4 + 0.2 X6 + D2 <=   39
       25)   X5 + 0.2 X6 + D3 <=   28
       26)   X1 + 0.3 X5 + D1 + 0.3 D3 <=   37
       27)   X2 + 0.25 X5 + 0.25 D3 <=   38
       28)   X3 + 0.25 X5 + 0.25 D3 <=   37
       29)   X4 + 0.3 X5 + D2 + 0.3 D3 <=   37
       30)   X1 + 0.35 X4 + D1 + 0.35 D2 <=   42
       31)   X2 + 0.3 X4 + 0.3 D2 <=   41
       32)   X3 + 0.25 X4 + 0.25 D2 <=   41
       33)   X1 + 0.45 X3 + D1 <=   45
       34)   X2 + 0.35 X3 <=   42
       35)   X1 + 0.6 X2 + D1 <=   49
       36)   X1 >=   29
       37)   X4 >=   30.4
       38)   X1 + D1 <=   31.9
       39)   X4 + D2 <=   33.44
       40)   X5 + D3 <=   18.9
```

LP OPTIMUM FOUND AT STEP 16
OBJECTIVE FUNCTION VALUE 1) 11964710.0

VARIABLE	VALUE	REDUCED COST
X1	29.000000	.000000
X2	29.942500	.000000
X3	31.034440	.000000
X4	30.400000	.000000
X5	18.000000	.000000
X6	19.827500	.000000
X7	33.218330	.000000
X8	19.827500	.000000
D1	2.034500	.000000
D2	.930000	.000000
D3	.900000	.000000

ROW	SLACK OR SURPLUS	DUAL PRICES
2)	.942498	.000000
3)	1.034445	.000000
4)	.000000	-9999999.000000
5)	1.827499	.000000
6)	2.818332	.000000
7)	1.827499	.000000
8)	.000000	5.000000
9)	2.083377	.000000
10)	1.982805	.000000
11)	3.687250	.000000
12)	5.108625	.000000
13)	3.207002	.000000
14)	3.833419	.000000
15)	.000000	3.333333
16)	1.074752	.000000
17)	1.982805	.000000
18)	3.687250	.000000
19)	4.117250	.000000
20)	2.528835	.000000
21)	.000000	5.000000
22)	1.092002	.000000
23)	2.000056	.000000
24)	3.704500	.000000
25)	5.134501	.000000
26)	.295500	.000000
27)	3.332502	.000000
28)	1.240555	.000000
29)	.000000	650006.000000
30)	.000000	999982.800000
31)	1.658501	.000000
32)	2.133055	.000000
33)	.000000	2.222222
34)	1.195446	.000000
35)	.000000	1.666667
36)	.000000	-999999.000000
37)	.000000	-999999.000000
38)	.865499	.000000
39)	2.109999	.000000
40)	.000000	9804998.000000

NO. ITERATIONS= 16

RANGES IN WHICH THE BASIS IS UNCHANGED:

		OBJ COEFFICIENT RANGES	
VARIABLE	CURRENT COEF	ALLOWABLE INCREASE	ALLOWABLE DECREASE
X1	1.000000	999999.000000	INFINITY
X2	1.000000	599989.700000	1.000000
X3	1.000000	449992.200000	1.000000
X4	1.000000	999999.000000	INFINITY
X5	1.000000	9999999.000000	INFINITY
X6	1.000000	199996.500000	1.000000
X7	1.000000	299994.800000	1.000000
X8	1.000000	199996.500000	1.000000
D1	1000000.000000	1857160.000000	999982.800000
D2	1000000.000000	32683330.000000	650006.000000
D3	10000000.000000	INFINITY	9804998.000000

RIGHTHAND SIDE RANGES

ROW	CURRENT RHS	ALLOWABLE INCREASE	ALLOWABLE DECREASE
2	29.000000	.942498	INFINITY
3	30.000000	1.034445	INFINITY
4	18.000000	.900000	18.000000
5	18.000000	1.827499	INFINITY
6	30.400000	2.818332	INFINITY
7	18.000000	1.827499	INFINITY
8	35.000000	2.555613	.365500
9	35.000000	INFINITY	2.083377
10	35.000000	INFINITY	1.982805
11	37.000000	INFINITY	3.687250
12	25.000000	INFINITY	5.108625
13	27.000000	INFINITY	3.207002
14	43.000000	INFINITY	3.833419
15	41.000000	1.150026	.845500
16	36.000000	INFINITY	1.074752
17	38.000000	INFINITY	1.982805
18	40.000000	INFINITY	3.687250
19	28.000000	INFINITY	4.117250
20	29.000000	INFINITY	2.528835
21	35.000000	.505767	.365500
22	35.000000	INFINITY	1.092002
23	37.000000	INFINITY	2.000056
24	39.000000	INFINITY	3.704500
25	28.000000	INFINITY	5.134501
26	37.000000	INFINITY	.295500
27	38.000000	INFINITY	3.332502
28	37.000000	INFINITY	1.240555
29	37.000000	1.170002	.844285
30	42.000000	.295500	.409501
31	41.000000	INFINITY	1.658501
32	41.000000	INFINITY	2.133055
33	45.000000	.558250	.465500
34	42.000000	INFINITY	1.195446
35	49.000000	.644851	.565499
36	29.000000	2.034500	29.000000
37	30.400000	.930000	30.400000
38	31.900000	INFINITY	.865499
39	33.440000	INFINITY	2.109999
40	18.900000	.729629	.900000

```
MAX      X1 + X2 + X3 + X4 + X5 + X6 + X7 + X8 + 100000 D1 + 1000000 D2
     + 10000000 D3

SUBJECT TO
         2)   X2 >=   29
         3)   X3 >=   30
         4)   X5 >=   18
         5)   X6 >=   18
         6)   X7 >=   30.4
         7)   X8 >=   18
         8)   X1 + 0.2 X8 + D1 <=   35
         9)   X2 + 0.15 X8 <=   35
        10)   X3 + 0.1 X8 <=   35
        11)   X4 + 0.1 X8 + D2 <=   37
        12)   X5 + 0.05 X8 + D3 <=   25
        13)   X6 + 0.2 X8 <=   27
        14)   X7 + 0.3 X8 <=   43
        15)   X1 + 0.3 X7 + D1 <=   41
        16)   X2 + 0.15 X7 <=   36
        17)   X3 + 0.15 X7 <=   38
        18)   X4 + 0.15 X7 + D2 <=   40
        19)   X5 + 0.15 X7 + D3 <=   28
        20)   X6 + 0.2 X7 <=   29
        21)   X1 + 0.2 X6 + D1 <=   35
        22)   X2 + 0.2 X6 <=   35
        23)   X3 + 0.2 X6 <=   37
        24)   X4 + 0.2 X6 + D2 <=   39
        25)   X5 + 0.2 X6 + D3 <=   28
        26)   X1 + 0.3 X5 + D1 + 0.3 D3 <=   37
        27)   X2 + 0.25 X5 + 0.25 D3 <=   38
        28)   X3 + 0.25 X5 + 0.25 D3 <=   37
        29)   X4 + 0.3 X5 + D2 + 0.3 D3 <=   37
        30)   X1 + 0.35 X4 + D1 + 0.35 D2 <=   42
        31)   X2 + 0.3 X4 + 0.3 D2 <=   41
        32)   X3 + 0.25 X4 + 0.25 D2 <=   41
        33)   X1 + 0.45 X3 + D1 <=   45
        34)   X2 + 0.35 X3 <=   42
        35)   X1 + 0.6 X2 + D1 <=   49
        36)   X1 >=   29
        37)   X4 >=   30.4
        38)   X1 + D1 <=   31.9
        39)   X4 + D2 <=   31.92
        40)   X5 + D3 <=   18.9
```

LP OPTIMUM FOUND AT STEP 16
OBJECTIVE FUNCTION VALUE 1) 10133660.0

VARIABLE	VALUE	REDUCED COST
X1	29.000000	.000000
X2	29.942500	.000000
X3	31.034440	.000000
X4	30.400000	.000000
X5	18.000000	.000000
X6	19.827500	.000000
X7	33.218330	.000000
X8	19.827500	.000000
D1	2.034500	.000000
D2	.930000	.000000
D3	.900000	.000000

ROW	SLACK OR SURPLUS	DUAL PRICES
2)	.942498	.000000
3)	1.034445	.000000
4)	.000000	-9999999.000000
5)	1.827499	.000000
6)	2.818332	.000000
7)	1.827499	.000000
8)	.000000	5.000000
9)	2.083377	.000000
10)	1.982805	.000000
11)	3.687250	.000000
12)	5.108625	.000000
13)	3.207002	.000000
14)	3.833419	.000000
15)	.000000	3.333333
16)	1.074752	.000000
17)	1.982805	.000000
18)	3.687250	.000000
19)	4.117250	.000000
20)	2.528835	.000000
21)	.000000	5.000000
22)	1.092002	.000000
23)	2.000056	.000000
24)	3.704500	.000000
25)	5.134501	.000000
26)	.295500	.000000
27)	3.332502	.000000
28)	1.240555	.000000
29)	.000000	965006.000000
30)	.000000	99982.780000
31)	1.658501	.000000
32)	2.133055	.000000
33)	.000000	2.222222
34)	1.195446	.000000
35)	.000000	1.666667
36)	.000000	-99999.000000
37)	.000000	-999999.000000
38)	.865499	.000000
39)	.590000	.000000
40)	.000000	9710498.000000

NO. ITERATIONS= 16

RANGES IN WHICH THE BASIS IS UNCHANGED:

OBJ COEFFICIENT RANGES

VARIABLE	CURRENT COEF	ALLOWABLE INCREASE	ALLOWABLE DECREASE
X1	1.000000	99999.000000	INFINITY
X2	1.000000	59989.670000	1.000000
X3	1.000000	44992.250000	1.000000
X4	1.000000	999999.000000	INFINITY
X5	1.000000	9999999.000000	INFINITY
X6	1.000000	19996.560000	1.000000
X7	1.000000	29994.840000	1.000000
X8	1.000000	19996.560000	1.000000
D1	100000.000000	2757160.000000	99982.780000
D2	1000000.000000	32368330.000000	965006.000000
D3	10000000.000000	INFINITY	9710498.000000

RIGHTHAND SIDE RANGES

ROW	CURRENT RHS	ALLOWABLE INCREASE	ALLOWABLE DECREASE
2	29.000000	.942498	INFINITY
3	30.000000	1.034445	INFINITY
4	18.000000	.900000	18.000000
5	18.000000	1.827499	INFINITY
6	30.400000	2.818332	INFINITY
7	18.000000	1.827499	INFINITY
8	35.000000	2.555613	.365500
9	35.000000	INFINITY	2.083377
10	35.000000	INFINITY	1.982805
11	37.000000	INFINITY	3.687250
12	25.000000	INFINITY	5.108625
13	27.000000	INFINITY	3.207002
14	43.000000	INFINITY	3.833419
15	41.000000	1.150026	.845500
16	36.000000	INFINITY	1.074752
17	38.000000	INFINITY	1.982805
18	40.000000	INFINITY	3.687250
19	28.000000	INFINITY	4.117250
20	29.000000	INFINITY	2.528835
21	35.000000	.505767	.365500
22	35.000000	INFINITY	1.092002
23	37.000000	INFINITY	2.000056
24	39.000000	INFINITY	3.704500
25	28.000000	INFINITY	5.134501
26	37.000000	INFINITY	.295500
27	38.000000	INFINITY	3.332502
28	37.000000	INFINITY	1.240555
29	37.000000	.590000	.844285
30	42.000000	.295500	.409501
31	41.000000	INFINITY	1.658501
32	41.000000	INFINITY	2.133055
33	45.000000	.558250	.465500
34	42.000000	INFINITY	1.195446
35	49.000000	.644851	.565499
36	29.000000	2.034500	29.000000
37	30.400000	.930000	30.400000
38	31.900000	INFINITY	.865499
39	31.920000	INFINITY	.590000
40	18.900000	.729629	.900000

```
MAX      X1 + X2 + X3 + X4 + X5 + X6 + X7 + X8 + 100000 D1 + 10000000 D2
     + 1000000 D3

SUBJECT TO
        2)    X2 >=   29
        3)    X3 >=   30
        4)    X5 >=   18
        5)    X6 >=   18
        6)    X7 >=   30.4
        7)    X8 >=   18
        8)    X1 + 0.2 X8 + D1 <=   35
        9)    X2 + 0.15 X8 <=   35
       10)    X3 + 0.1 X8 <=   35
       11)    X4 + 0.1 X8 + D2 <=   37
       12)    X5 + 0.05 X8 + D3 <=   25
       13)    X6 + 0.2 X8 <=   27
       14)    X7 + 0.3 X8 <=   43
       15)    X1 + 0.3 X7 + D1 <=   41
       16)    X2 + 0.15 X7 <=   36
       17)    X3 + 0.15 X7 <=   38
       18)    X4 + 0.15 X7 + D2 <=   40
       19)    X5 + 0.15 X7 + D3 <=   28
       20)    X6 + 0.2 X7 <=   29
       21)    X1 + 0.2 X6 + D1 <=   35
       22)    X2 + 0.2 X6 <=   35
       23)    X3 + 0.2 X6 <=   37
       24)    X4 + 0.2 X6 + D2 <=   39
       25)    X5 + 0.2 X6 + D3 <=   28
       26)    X1 + 0.3 X5 + D1 + 0.3 D3 <=   37
       27)    X2 + 0.25 X5 + 0.25 D3 <=   38
       28)    X3 + 0.25 X5 + 0.25 D3 <=   37
       29)    X4 + 0.3 X5 + D2 + 0.3 D3 <=   37
       30)    X1 + 0.35 X4 + D1 + 0.35 D2 <=   42
       31)    X2 + 0.3 X4 + 0.3 D2 <=   41
       32)    X3 + 0.25 X4 + 0.25 D2 <=   41
       33)    X1 + 0.45 X3 + D1 <=   45
       34)    X2 + 0.35 X3 <=   42
       35)    X1 + 0.6 X2 + D1 <=   49
       36)    X1 >=   29
       37)    X4 >=   30.4
       38)    X1 + D1 <=   31.9
       39)    X4 + D2 <=   31.92
       40)    X5 + D3 <=   18.9
```

LP OPTIMUM FOUND AT STEP 15
OBJECTIVE FUNCTION VALUE 1) 12194220.0

VARIABLE	VALUE	REDUCED COST
X1	29.000000	.000000
X2	30.100000	.000000
X3	31.244440	.000000
X4	30.400000	.000000
X5	18.000000	.000000
X6	20.300000	.000000
X7	33.533330	.000000
X8	20.300000	.000000
D1	1.940000	.000000
D2	1.200000	.000000
D3	.000000	1989502.000000

ROW	SLACK OR SURPLUS	DUAL PRICES
2)	1.099998	.000000
3)	1.244445	.000000
4)	.000000	-2989501.000000
5)	2.299998	.000000
6)	3.133332	.000000
7)	2.299998	.000000
8)	.000000	5.000000
9)	1.855002	.000000
10)	1.725555	.000000
11)	3.370000	.000000
12)	5.985000	.000000
13)	2.640002	.000000
14)	3.376669	.000000
15)	.000000	3.333333
16)	.870002	.000000
17)	1.725555	.000000
18)	3.370000	.000000
19)	4.970000	.000000
20)	1.993335	.000000
21)	.000000	5.000000
22)	.840002	.000000
23)	1.695556	.000000
24)	3.340000	.000000
25)	5.940000	.000000
26)	.660000	.000000
27)	3.400002	.000000
28)	1.255555	.000000
29)	.000000	9965006.000000
30)	.000000	99982.780000
31)	1.420001	.000000
32)	1.855555	.000000
33)	.000000	2.222222
34)	.964446	.000000
35)	.000000	1.666667
36)	.000000	-99999.000000
37)	.000000	-9999999.000000
38)	.959999	.000000
39)	.320000	.000000
40)	.900000	.000000

NO. ITERATIONS= 15

RANGES IN WHICH THE BASIS IS UNCHANGED:

OBJ COEFFICIENT RANGES

VARIABLE	CURRENT COEF	ALLOWABLE INCREASE	ALLOWABLE DECREASE
X1	1.000000	99999.000000	INFINITY
X2	1.000000	59989.670000	1.000000
X3	1.000000	44992.250000	1.000000
X4	1.000000	9999999.000000	INFINITY
X5	1.000000	2989501.000000	INFINITY
X6	1.000000	19996.560000	1.000000
X7	1.000000	29994.840000	1.000000
X8	1.000000	19996.560000	1.000000
D1	100000.000000	18947640.000000	99982.780000
D2	10000000.000000	INFINITY	6631673.000000
D3	1000000.000000	1989502.000000	INFINITY

RIGHTHAND SIDE RANGES

ROW	CURRENT RHS	ALLOWABLE INCREASE	ALLOWABLE DECREASE
2	29.000000	1.099998	INFINITY
3	30.000000	1.244445	INFINITY
4	18.000000	.900000	1.066668
5	18.000000	2.299998	INFINITY
6	30.400000	3.133332	INFINITY
7	18.000000	2.299998	INFINITY
8	35.000000	2.251113	.460000
9	35.000000	INFINITY	1.855002
10	35.000000	INFINITY	1.725555
11	37.000000	INFINITY	3.370000
12	25.000000	INFINITY	5.985000
13	27.000000	INFINITY	2.640002
14	43.000000	INFINITY	3.376669
15	41.000000	1.013001	.939999
16	36.000000	INFINITY	.870002
17	38.000000	INFINITY	1.725555
18	40.000000	INFINITY	3.370000
19	28.000000	INFINITY	4.970000
20	29.000000	INFINITY	1.993335
21	35.000000	.398667	.460000
22	35.000000	INFINITY	.840002
23	37.000000	INFINITY	1.695556
24	39.000000	INFINITY	3.340000
25	28.000000	INFINITY	5.940000
26	37.000000	INFINITY	.660000
27	38.000000	INFINITY	3.400002
28	37.000000	INFINITY	1.255555
29	37.000000	.320000	1.200000
30	42.000000	.460000	.315001
31	41.000000	INFINITY	1.420001
32	41.000000	INFINITY	1.855555
33	45.000000	.565000	.560000
34	42.000000	INFINITY	.964446
35	49.000000	.504001	.659999
36	29.000000	1.940000	29.000000
37	30.400000	1.200000	30.400000
38	31.900000	INFINITY	.959999
39	31.920000	INFINITY	.320000
40	18.900000	INFINITY	.900000

```
MAX     X1 + X2 + X3 + X4 + X5 + X6 + X7 + X8 + 1000000 D1 + 1000000 D2
     + 10000000 D3

SUBJECT TO
        2)   X2 >=   29
        3)   X3 >=   30
        4)   X5 >=   18
        5)   X6 >=   18
        6)   X7 >=   30.4
        7)   X8 >=   18
        8)   X1 + 0.22 X8 + D1 <=   38.5
        9)   X2 + 0.15 X8 <=   35
       10)   X3 + 0.1 X8 <=   35
       11)   X4 + 0.1 X8 + D2 <=   37
       12)   X5 + 0.05 X8 + D3 <=   25
       13)   X6 + 0.2 X8 <=   27
       14)   X7 + 0.3 X8 <=   43
       15)   X1 + 0.33 X7 + D1 <=   45.1
       16)   X2 + 0.15 X7 <=   36
       17)   X3 + 0.15 X7 <=   38
       18)   X4 + 0.15 X7 + D2 <=   40
       19)   X5 + 0.15 X7 + D3 <=   28
       20)   X6 + 0.2 X7 <=   29
       21)   X1 + 0.22 X6 + D1 <=   38.5
       22)   X2 + 0.2 X6 <=   35
       23)   X3 + 0.2 X6 <=   37
       24)   X4 + 0.2 X6 + D2 <=   39
       25)   X5 + 0.2 X6 + D3 <=   28
       26)   X1 + 0.33 X5 + D1 + 0.33 D3 <=   40.7
       27)   X2 + 0.25 X5 + 0.25 D3 <=   38
       28)   X3 + 0.25 X5 + 0.25 D3 <=   37
       29)   X4 + 0.3 X5 + D2 + 0.3 D3 <=   37
       30)   X1 + 0.385 X4 + D1 + 0.385 D2 <=   46.2
       31)   X2 + 0.3 X4 + 0.3 D2 <=   41
       32)   X3 + 0.25 X4 + 0.25 D2 <=   41
       33)   X1 + 0.495 X3 + D1 <=   49.5
       34)   X2 + 0.35 X3 <=   42
       35)   X1 + 0.66 X2 + D1 <=   53.9
       36)   X1 >=   29
       37)   X4 >=   30.4
       38)   X1 + D1 <=   31.9
       39)   X4 + D2 <=   33.44
       40)   X5 + D3 <=   18.9
```

LP OPTIMUM FOUND AT STEP 16

OBJECTIVE FUNCTION VALUE 1) 12830220.0

VARIABLE	VALUE	REDUCED COST
X1	29.000000	.000000
X2	30.500000	.000000
X3	32.000000	.000000
X4	30.400000	.000000
X5	18.000000	.000000
X6	21.000000	.000000
X7	34.000000	.000000
X8	30.000000	.000000
D1	2.900000	.000000
D2	.930000	.000000
D3	.900000	.000000

ROW	SLACK OR SURPLUS	DUAL PRICES
2)	1.500000	.000000
3)	2.000000	.000000
4)	.000000	-9999999.000000
5)	3.000000	.000000
6)	3.599999	.000000
7)	12.000000	.000000
8)	.000000	1.136364
9)	.000000	1.000000
10)	.000000	1.000000
11)	2.670000	.000000
12)	4.600000	.000000
13)	.000000	1.000000
14)	.000000	1.000000
15)	1.979999	.000000
16)	.400000	.000000
17)	.900000	.000000
18)	3.570000	.000000
19)	4.000000	.000000
20)	1.200001	.000000
21)	1.980000	.000000
22)	.300000	.000000
23)	.800000	.000000
24)	3.470000	.000000
25)	4.900001	.000000
26)	2.563001	.000000
27)	2.775001	.000000
28)	.275000	.000000
29)	.000000	1000000.000000
30)	2.237952	.000000
31)	1.101000	.000000
32)	1.167500	.000000
33)	1.760000	.000000
34)	.300001	.000000
35)	1.870001	.000000
36)	.000000	-999999.000000
37)	.000000	-999999.000000
38)	.000000	999998.900000
39)	2.109999	.000000
40)	.000000	9700000.000000

NO. ITERATIONS= 16

RANGES IN WHICH THE BASIS IS UNCHANGED:

OBJ COEFFICIENT RANGES

VARIABLE	CURRENT COEF	ALLOWABLE INCREASE	ALLOWABLE DECREASE
X1	1.000000	999999.000000	INFINITY
X2	1.000000	1.666667	1.000000
X3	1.000000	2.500000	1.000000
X4	1.000000	999999.000000	INFINITY
X5	1.000000	9999999.000000	INFINITY
X6	1.000000	1.250000	1.000000
X7	1.000000	.833333	1.000000
X8	1.000000	219999.800000	.250000
D1	1000000.000000	INFINITY	999998.900000
D2	1000000.000000	32333330.000000	999999.000000
D3	10000000.000000	INFINITY	9700000.000000

RIGHTHAND SIDE RANGES

ROW	CURRENT RHS	ALLOWABLE INCREASE	ALLOWABLE DECREASE
2	29.000000	1.500000	INFINITY
3	30.000000	2.000000	INFINITY
4	18.000000	.900000	18.000000
5	18.000000	3.000000	INFINITY
6	30.400000	3.599999	INFINITY
7	18.000000	12.000000	INFINITY
8	38.500000	2.199999	.347369
9	35.000000	.300000	1.500000
10	35.000000	.275000	2.000000
11	37.000000	INFINITY	2.670000
12	25.000000	INFINITY	4.600000
13	27.000000	1.200001	3.000000
14	43.000000	2.666669	3.599999
15	45.100000	INFINITY	1.979999
16	36.000000	INFINITY	.400000
17	38.000000	INFINITY	.900000
18	40.000000	INFINITY	3.570000
19	28.000000	INFINITY	4.000000
20	29.000000	INFINITY	1.200001
21	38.500000	INFINITY	1.980000
22	35.000000	INFINITY	.300000
23	37.000000	INFINITY	.800000
24	39.000000	INFINITY	3.470000
25	28.000000	INFINITY	4.900001
26	40.700000	INFINITY	2.563001
27	38.000000	INFINITY	2.775001
28	37.000000	INFINITY	.275000
29	37.000000	2.109999	.930000
30	46.200000	INFINITY	2.237952
31	41.000000	INFINITY	1.101000
32	41.000000	INFINITY	1.167500
33	49.500000	INFINITY	1.760000
34	42.000000	INFINITY	.300001
35	53.900000	INFINITY	1.870001
36	29.000000	2.900000	29.000000
37	30.400000	.930000	30.400000
38	31.900000	.347369	2.199999
39	33.440000	INFINITY	2.109999
40	18.900000	1.100001	.900000