Commonwealth Edison
One First National Plaza, Chicago, Illinois
Address Reply to: Post Office Box 767
Chicago, Illinois 60690

March 23, 1979

Mr. Olan D. Parr, Chief
Light Water Reactors - Branch 3
Division of Project Management
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: LaSalle County Station Units 1 and 2
Mark II Containment
NRC Docket Nos. 50-373/374

References (a): C. Reed letter to O. D. Parr dated December 1, 1978

(b): O. D. Parr letter to B. Lee, Jr. dated February 1979

(c): L. O. DelGeorge letter to O. D. Parr dated February 23, 1979

Dear Mr. Parr:

As indicated in Reference (a), Commonwealth Edison agreed to adopt the NRC lead plant acceptance criteria with a limited number of exceptions. That agreement was, in several cases, contingent upon favorable consideration by the Nuclear Regulatory Commission (NRC) of the application of SRSS methodology.

In response to the information request made by the NRC Staff in Reference (b), Commonwealth Edison provided in Reference (c) the schedule by which the Mark II Owners would provide the information judged by the Staff to be necessary.

The attached revision to the LaSalle County Station Design Assessment Report provides the outstanding information described in Reference (c). It is the judgement of this applicant that all the information necessary to resolve the "open" Mark II Containment issues has now been provided to the NRC Staff for review.

7904030263

A

Three (3) signed originals and thirty-seven (37) copies of this revision are submitted for your review.

Very truly yours,

per/ L.O. DelGeorge

Cordell Reed
Assistant Vice-President

attachment

SUBSCRIBED and SWORN to
before me this 23rd day
of March, 1979.

Anna M. Dascenzo
Notary Public

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L. O. DelGeorge

for/ Cordell Reed
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Nancy M. Rosenberg
Notary Public

LA SALLE COUNTY POWER STATION

INSTRUCTIONS FOR UPDATING YOUR MARK II DAR

To update your copy of the LSCS-MARK II DAR, remove and destroy the following pages and insert pages and figure as indicated.

REMOVE	INSERT
Pages v through xi	Pages v through xii
Page for Tab, Appendix C	Tab Appendix C
Page C.0-1	Page C.0-1
Pages C.1-1 through C.1-11	Pages C.1-1 through C.1-14
	Pages C.2-1 through C.2-5
	Pages C.3-1 through C.3-3
	Tab Appendix D
	Pages D.1-1 through D.1-12
	Figure D.1-1

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LIST OF FIGURES (Cont'd)

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LIST OF FIGURES (Cont'd)

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C.0 LA SALLE DESIGN BASIS VS. NRC LEAD PLANT ACCEPTANCE CRITERIA

This appendix provides an assessment of the current design basis for the La Salle County Station against the NRC "Mark II Generic Acceptance Criteria for Lead Plants" of September 18, 1978. This comparison and the information provided, reflects the Mark II Lead Plant positions discussed with the NRC staff on October 19, 1978. The positions assume that the Newmark/Kennedy Criteria for use of the SRSS method of load combination will be accepted. In areas where the La Salle position differs from the NRC Acceptance Criteria, support will be provided by Mark II Owners Group Tasks and by La Salle unique efforts as appropriate. | 5

C.1 COMPARISON SUMMARY

This section provides in a tabular form the results of the comparison between the plant current design basis and the lead plant acceptance criteria. 5

LOAD OR PHENOMENON	MARK II OWNERS GROUP LOAD SPECIFICATION	NRC REVIEW STATUS	LA SALLE POSITION ON ACCEPTANCE CRITERIA
I. LOCA-Related Hydrodynamic Loads			
A. Submerged Boundary Loads During Vent Clearing	33 psi over-pressure added to local hydrostatic below vent exit (walls and basemat) - linear attenuation to pool surface.	Acceptable	Acceptable. However, it should be noted that 33 psi is a very conservative estimation of jet loads which should be applied only to the basemat in accordance with DFFR (Rev. 2). The Mark II program will provide a realistic assessment of wall loads during vent clearing based on 4T results.
B. Pool Swell Loads 1. Pool Swell Analytical Model			
a) Air Bubble Pressure	Calculated by the Pool Swell Analytical Model (PSAM) used in calculation of submerged boundary loads.	Acceptable	————
b) Pool Swell Elevation	1.5 x submergence.	NRC Criteria I.A.1	Acceptable
c) Pool Swell Velocity	Velocity history vs. pool elevation predicted by the PSAM used to compute impact loading on small structures and drag on gratings between initial pool surface and maximum pool elevation and steady-state drag between vent exit and maximum pool elevation. Analytical velocity variation used up to maximum velocity. Maximum velocity applies thereafter up to maximum pool swell.	NRC Criteria I.A.2	Acceptable The impact of a 10% increase in pool swell velocity will be assessed. Although the assumptions used in the Pool Swell Analytical Model are already very conservative and eliminate the need for any additional factors, the resulting calculated load increase should not require design changes since there are only a minimum of components in the pool swell region of the wetwell.
d) Pool Swell Acceleration	Acceleration predicted by the PSAM. Pool acceleration is utilized in the calculation of acceleration drag loads on submerged components during pool swell.	Acceptable	
e) Wetwell Air Compression	Wetwell air compression is calculated by the PSAM. Defines the pressure loading on the wetwell boundary above the pool surface during pool swell.	Acceptable	————

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LOAD OR PHENOMENON	MARK II OWNERS GROUP LOAD SPECIFICATION	NRC REVIEW STATUS	LA SALLE POSITION ON ACCEPTANCE CRITERIA
f) Drywell Pressure History	Plant unique. Utilized to PSAM to calculate pool swell loads.	Acceptable if based on NEDM-10320. Otherwise plant unique reviews required.	Acceptable.
2. Loads on Submerged Boundaries	Maximum bubble pressure predicted by the PSAM added uniformly to local hydrostatic below vent exit (wells and basemat) linear attenuation to pool surface. Applied to walls up to maximum pool swell elevation.	Acceptable	————
3. Impact Loads			
a) Small Structures	1.5 x Pressure-Velocity correlation for pipes and I beams. Constant duration pulse.	NRC criteria I.A.6	Acceptable. Although the criteria is unnecesarily conservative investigations indicate that, due to the size and frequency of structures in the La Salle pool swell zone, the design loads used are conservative with respect to the NRC Acceptance Criteria. It should be noted that analytical work performed by Sargent & Lundy utilizing the PSTF (Pressure Suppression Test Facility) data for circumferential targets indicates that the DFFR specification is conservative for the size and frequency of structures in the La Salle Pool Swell Zone. Tests performed by EPRI (EPRI No. NP-798, May 1978) to determine flat pool impact on rigid and flexible cylinders are also in good agreement with DFFR. The Maise report employed excessively conservative assumptions to define areas where DFFR is nonconservative. The NRC Acceptance Criteria utilized an additional assumption (I-beam impact duration is inversely proportional to velocity) which is inconsistent with theory and experimental evidence. Nevertheless, the NRC Criteria have been used to assess structures in the pool swell zone and these structures can withstand the conservative criteria.
b) Large Structures	None - Plant unique load where applicable.	Plant unique review where applicable	
c) Grating	No impact load specified. P_{drag} vs. open area correlation and velocity vs. elevation history from the PSAM.	NRC Criteria I.A.3	Acceptable. La Salle has no grating in pool swell area.

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LOAD OR PHENOMENON	MARK II OWNERS GROUP LOAD SPECIFICATION	NRC REVIEW STATUS	LA SALLE POSITION ON ACCEPTANCE CRITERIA
4. Wetwell Air Compression			
a) Wall Loads	Direct application of the PSAM calculated pressure due to wet-well compression.	Acceptable	__________
b) Diaphragm Upward Loads	2.5 psid	NRC Criteria I.A.4	Acceptable
5. Asymmetric Load	None	NRC Criteria I.A.5	Open Item. Although this load is unnecessarily conservative, a simplified assessment has been completed which shows that the current design can take this load. This assessment utilized the vent clearing pressure load (22 psig) applied over a 180 sector of the wetwell wall between the basemat and the drywell floor. Superimposed on this was the hydrostatic load (12 psig at basemat with linear decrease to zero at the water surface) applied over the entire wetwell wall between the basemat and pool surface. This load has been found to be of little significance compared to other design loads and does not affect the adequacy of the design. An analysis of data from the Maruiken tests, indicates that even in a geometry which conservatively bounds the Mark II geometry, the asymmetric load is less than 10% of the maximum load. This will be documented in a generic Mark II submittal.
C. Steam Condensation and Chugging Loads			
1. Downcomer Lateral Loads			
a) Single Vent Loads	8.8 KIP static	NRC Criteria I.B.1	Acceptable
b) Multiple Vent loads	Prescribes variation of load per downcomer vs. number of downcomers.	NRC Criteria I.B.2	Acceptable
2. Submerged Boundary Loads			
a) High Steam Flux Loads	Sinusoidal pressure fluctuation added to local hydrostatic. Aplitude uniform below vent exit-linear attenuation to pool surface. 4.4 psi peak-to-peak amplitude. 2, 6, 7 Hz frequencies.	Acceptable	__________

LOAD OR PHENOMENON	MARK II OWNERS GROUP LOAD SPECIFICATION	NRC REVIEW STATUS	LA SALLE POSITION ON ACCEPTANCE CRITERIA
b) Medium Steam Flux Loads	Sinusoidal pressure fluctuation added to local hydrostatic. Amplitude uniform below vent exit-linear attenuation to pool surface. 7.5 psi peak-to-peak amplitude. 5, 6 Hz frequencies.	Acceptable	———
c) Chugging Loads	Representative pressure fluctuation taken from 4T test added to local hydrostatic.	Acceptable pending resolution of FSI concerns.	———
- uniform loading condition	Maximum amplitude uniform below vent exit-linear attenuation to pool surface. +4.8 psi maximum overpressure, -4.0 psi maximum under pressure, 20-30 Hz frequency.		
- asymmetric loading condition	Maximum amplitude uniform below vent exit-linear attenuation to pool surface. 20 psi maximum overpressure, -14 psi maximum underpressure, 20-30 Hz frequency, peripheral variation of amplitude follows observed statistical distribution with maximum and minimum diametrically opposed.		

LOAD OR PHENOMENON	MARK II OWNERS GROUP LOAD SPECIFICATION	NRC REVIEW STATUS	LA SALLE POSITION ON ACCEPTANCE CRITERIA
II. SRV-Related Hydrodynamic Loads			
A. Pool Temperature Limits for KWU and GE four arm quencher	None specified	NRC Criteria II.1 and II.3	Acceptable
Quencher Air Clearing Loads	Mark II plants utilizing the quencher use an interim load specification consisting of the rams head calculational procedure. Mark II plants utilizing the four arm quencher use quencher load methodology described in DFFR.	NRC Criteria II.2	Open Item. The first four SRV discharge cases listed in the NRC Acceptance Criteria are being assessed. In addition, a simultaneous valve actuation case is considered. The cases considered and the phasing involved were discussed with the NRC in the December 12, 1978 meeting. This material is documented in Section C.2. Analytical models have been used to predict forcing function frequencies for the load cases considered. Because of the wide range of discharge conditions considered the frequency range used exceeds the 4-11 Hz. range specified. A presentation on the impact of modifications to the SRV frequency range was given in the February 13, 1979 meeting. This information will be documented on the Shoreham docket in March 1979. When this documentation is appropriately identified, it will be referenced for La Salle. In-plant tests will be run to demonstrate the adequacy and conservatism of the design loads.
B. Quencher Tie-Down Loads			
1. Quencher Arm Loads			
(a) Four Arm Quencher	Vertical and lateral arm loads developed on the basis of bounding assumptions for air/water discharge from the quencher and conservative combinations of maximum/minimum bubble pressure acting on the quencher.	Acceptable	

LOAD OR PHENOMENON	MARK II OWNERS GROUP LOAD SPECIFICATION	NRC REVIEW STATUS	LA SALLE POSITION ON ACCEPTANCE CRITERIA
(b) KWU T Quencher	KWU "T" quencher not included in Mark II O.G. Program. T quencher arm loads not specified at this time.	Review Continuing	Acceptable. These loads will be calculated using the methodology and assumptions described in DFFR for four arm quenchers, as recommended in the Acceptance Criteria.
2. Quencher Tie-Down Loads			
(a) Four-Arm Quencher	Includes vertical and lateral arm load transmitted to the basemat via the tie downs. See II.C.1.a above plus vertical transient wave and thrust loads. Thrust load calculated using a standard momentum balance. Vertical and lateral moments for air or water clearing are calculated based on conservative clearing assumptions.	Acceptable	________
(b) KWU "T" Quencher	KWU "T" quencher not included in Mark II O.G. program. T quencher tie-down loads not specified at this time.	Review Continuing	Acceptable. These loads will be calculated using the methodology and assumptions described in DFFR for four arm quenchers, as recommended in the Acceptance Criteria.
III. LOCA/SRV Submerged Structure Loads			
A. LOCA/SRV Jet Loads			
1. LOCA/Rams head SRV Jet Loads	Methodology based on a quasi-one-dimensional model.	NRC Criteria III.A.1	See Section C.3
2. SRV-Quencher Jet Loads	No loads specified for lead plants. Model under development in long-term program.	NRC Criteria III.A.2	Open Item. The spherical zone of influence defined in the Acceptance Criteria is not approppriate for the two arm quencher. A zone of influence for each arm will be defined as a cylinder with an axis coincidental with the quencher arm. The length of the cylinder will be equal to the length of the quencher arm plus 10 end cap hole diameters. The radius of the cylinder is expected to be quite small. However, because no structures are within 5 feet of the quencher arm, 5 feet will be assumed. Since no structures are located within 5 feet of the quencher, the NRC Criterion III.A.2 is now satisfied.

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LOAD OR PHENOMENON	MARK II OWNERS GROUP LOAD SPECIFICATION	NRC REVIEW STATUS	LA SALLE POSITION ON ACCEPTANCE CRITERIA
B. LOCA/SRV Air Bubble Drag Loads			Open Item
1. LOCA Air Bubble Loads	The methodology follows the LOCA air carryover phase from bubble charging, bubble contract, pool rise and pool fallback. The drag calculations include standard and acceleration drag components.	NRC Criteria III.B.1.	The NRC Acceptance Criteria required modification to the present methodology in several areas. Resolution has been reached in most cases. Generic documentation will be provided in a Mark II Owners Group submittal. For La Salle County Station, these items have been addressed as follows:

a) Bubble Asymmetry – Although bubble asymmetry has been in the NRC Criteria, the conservatisms used in modeling the LOCA blowdown are sufficient to account for the small asymmetric effects postulated. No additional multipliers are necessary on the fluid velocity.

b) Standard Drag in Accelerating Flows - Standard drag is affected by the characteristics of an accelerating flow. Information is available in the literature (References 1, 2, and 3) to assess the effects on drag coefficients. LOCA air charging is considered a constant acceleration situation to which Reference 1 applies. Pool swell may be considered a portion of an oscillatory flow. Reference 2 or Reference 3 is used depending upon the Reynolds number. 5

c) Velocity and Acceleration Definition - Submerged structure loads are computed by subdividing the structure into segments and calculating drag loads based upon the velocity and acceleration predicted at the midpoint of the segment in a uniform flow field. This is the accepted procedure for calculating drag loads and is expected to cause no inaccuracies. 5

To verify the adequacy of this method, a sensitivity study was performed. A basic guideline has been established requiring L/D (ratio of length of segment to diameter) to be approximately $1.0 \leq L/D \leq 1.5$. To test this guideline, a typical structure was analyzed at L/D ratios of 1.5, 0.75, and 0.1875. The resulting acceleration and velocity step functions were compared by calculating the area under the curves at various times. The areas varied by less than 0.10%. This study will be documented by the Mark II generic program. 5

d) Interference Effects - Drag loads may be increased or decreased when structures are located close to each other or to boundaries. Based upon the structures size, separation, stagger angle and the type of flow, appropriate factors may be found in the literature to modify both acceleration and standard drag. Reference 4 through 10 are used to assess the effect of interference. 5

LOAD OR PHENOMENON	MARK II OWNERS GROUP LOAD SPECIFICATION	NRC REVIEW STATUS	LA SALLE POSITION ON ACCEPTANCE CRITERIA
			e) Interference in Downcomer Bracing - Does not apply to La Salle.
2. SRV-Rams Head Air Bubble Loads	The methodology is based on an analytical model of the bubble charging process including bubble rise and oscillation. Acceleration drag alone is considered.	NRC Criteria III.B.2	Open Item a) Neglecting Standard Drag - Standard drag is calculated and included for all submerged structure load calculations. b) LOCA Bubble Criteria - The LOCA air bubble comments also apply to the SRV bubbles. 5
3. SRV-Quencher Air Bubble Loads	No quencher drag model provided for lead plants. Lead plants propose interim use of rams head model (See III.B.2 above). Model will be developed in long-term program.	NRC Criteria III.B.3.	Open Item The bubble location and radius recommended in the acceptance criteria is not appropriate for T-quenchers. Bubbles are actually located near the arms. The bubble size is predicted from the line air volume.
C. Steam Condensation Drag Loads	No generic load methodology provided. Generic model under development in long-term program.	Lead plant load specification and NRC review will be conducted on a plant unique basis with confirmation in long-term program using generic model.	Described in La Salle Closure Report

LOAD OR PHENOMENON	MARK II OWNERS GROUP LOAD SPECIFICATION	NRC REVIEW STATUS	LA SALLE POSITION ON ACCEPTANCE CRITERIA
IV. Secondary Loads			5
A. Sonic Wave Load	Negligible Load - none specified	Acceptable	__________
B. Compressive Wave Load	Negligible Load - none specified	Acceptable	__________
C. Post Swell Wave Load	No generic load provided	Plant unique load specification and NRC review.	Described in La Salle Closure Report
D. Seismic Slosh Load	No generic load provided	Plant unique load specification and NRC review.	Described in La Salle Closure Report
E. Fallback load on Submerged Boundary	Negligible load - none specified	Acceptable	__________
F. Thrust Loads	Momentum balance	Acceptable	__________
G. Friction Drag Loads on Vents	Standard friction drag calculations	Acceptable	__________
H. Vent Clearing Loads	Negligible Load - none specified	Acceptable	__________

LOAD OR PHENOMENON	MARK II OWNERS GROUP LOAD SPECIFICATION	NRC REVIEW STATUS	LA SALLE POSITION ON ACCEPTANCE CRITERIA
FUNCTIONAL CAPABILITY		Interim technical position (7/19/78)	Acceptable, Rodabaugh criteria may be used in some cases if NRC finds acceptable.
MASS-ENERGY RELEASE FOR ANNULUS PRESS.		Verify using RELAP4/MOD5	Acceptable
QUESTIONS MEB-2, MEB-5		15% peak broadening to be used.	Acceptable
MEB-3, MEB-5		Closely spaced modes combined Per 1.92	Acceptable. NSSS scope uses modified summation per approved GESSAR.
MEB-1		Dynamic analysis methods acceptable	Acceptable
MEB-2		OBE Damping - Level A or B SSE Damping - Level C or D	Acceptable
MEB-6		Seismic slosh-plant unique review	Acceptable
MEB-7a and b		Load Combinations: AP+SSE OBE+SRV	Acceptable. See load combination table for Case #2 and 7
MEB-8		Functional capability and piping acceptance criteria	See load combination table.

LOAD PHENOMENON	MARK II OWNERS GROUP LOAD SPECIFICATION	NRC REVIEW STATUS	LA SALLE POSITION ON ACCEPTANCE CRITERIA
1.		$N+SRV_x$ To B	Acceptable
2.		$N+SRV_x+OBE$ to B	Acceptable Approved GESSAR approach used for NSSS.
3.		$N+SRV_{all}+SSE$ to C	Acceptable
4.		$N+SRV_{ads}+OBE+IBA$ to C	Acceptable
5.		$N+SRV_{ads}+OBE+IBA$ to C	Acceptable
6.		$N+SRV_{ads}+SSE+IBA$ to C	Acceptable
7.		N+SSE+DBA to C	Acceptable
8.		N to A	Acceptable
9.		N+OBE to B	Acceptable
10.		$N+SRV_s+SSE+DBA$ to C	Applied to containment structure only (See M 020.22 and DFFR 5.2.4, and letter to R. J. Mattson from L. J. Sobon dated Feb. 22, 1979). 5

REFERENCES

1. T. Sarpkaya, and C. J. Garrison, "Vortex Formation and Resistance in Unsteady Flow," Journal of Applied Mechanics, pp. 16-24.

2. T. Sarpkaya, "Forces on Cylinders and Spheres in a Sinusoidally Oscillating Fluid," Transactions of the ASME, March 1975, pp. 32-37.

3. T. Sarpkaya, "Vortex Shedding and Resistance in Harmonic Flow About Smooth and Rough Circular Cylinders at High Reynolds Numbers," NPS-59SL76021, February 1976, pg. 63.

4. C. Dalton and J. M. Szabo, "Drag on a Group of Cylinders" Transactions of the ASME, Journal of the Pressure Vessel Technology, February 1977, pp. 152-157. 5

5. B. I. Hori, "Experiments on Flow Around a Fair of Parallel Circular Cylinders", Proceedings of the 9th Japan National Congress for Applied Mechanics, 1959, pp. 231-234.

6. C. Dalton, and R. A. Helfinstein, "Potential Flow Past a Group of Circular Cylinders", Journal of Basic Engineering, ASME, December 1971, pp. 636-642.

7. T. Yamamoto, and J. H. Nath, "Forces on Many Cylinders Near a Plane Boundary", Presented at the April 5-8, 1976, ASCE National Water Resources and Ocean Eng. Convention, held at San Diego, California (Preprint 2633).

8. T. Yamamoto, "Hydrodynamic Forces on Multiple Circular Cylinders", Journal of the Hydraulics Division, ASCE, September 1976, pp. 1193-1210.

9. T. Sarpkaya, "In-Line and Transverse Forces on Cylinders Near a Wall in Oscillatory Flow at High Reynolds Numbers", Presented at Offshore Technology Conference, May 1977. 5

10. T. Sarpkaya, "Forces on Cylinders Near a Plane Boundary in a Sinusoidally Oscillating Fluid", "Journal of Fluids Engineering, ASME, September 1976, pp. 499-505.

C.2 ACCEPTANCE CRITERION II.A.2

C.2.1 Time Phasing of Bubble Dynamics for Multiple Valve Actuations

When multiple SRV vent lines discharge into a suppression pool, the relative timing among the air bubbles' dynamics depends on individual characteristics of the valves and lines involved. In the calculation of dynamic loads, the following factors may be taken into account for various postulated discharge cases:

Main steam supply pressure transient.

SRV pressure setpoint.

Vent line characteristics (length, diameter, equivalent friction factors, etc.).

Initial conditions in line.

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The supply pressure (including its time rate of increase) and S/RV setpoint determine each valve's actuation time. The line characteristics and initial conditions determine each line's clearing time as well as bubble formation times and dynamics (bubble pressure, radius and depth versus time). Appropriate vent clearing times is calculated by using the vent clearing model provided in Reference 1. The line clearing time is accurately calculated as demonstrated by a predicted clearing time of 240 ms compared to a range of 200-300 ms indicated by test data (Reference 2) for the same clearing transient. The valve flow rate was calculated using a conservative method which gives flow 22.5% higher than expected. A conservatively short valve opening time is also used which will maximize the bubble pressures.

The bounding load approach taken in design assessment calculations is to postulate a number of conceivable discharge situations, then mechanistically calculate the suppression pool loading

functions for each case, and finally select the bounding case on the basis of the load function or its structural response. The bounding discharge case usually varies depending on the configuration of the loaded structure. That is, major structural loads on the pedestal, basemat and containment are often bounded for a different discharge case than are loads on submerged structures, such as support columns, downcomers, and SRV vent lines themselves. The discharge cases must also include bounding structural loads for forces in the vertical and horizontal directions as well as bounding "rocking" moments. Mechanistic calculations include individual vent line transients, air bubble dynamics, and the load factors which relate bubble dynamics to pressure or drag forces on specific structures. Each calculation is unique to each plant, structure and discharge case.

The following discharge cases have been used for design assessment as reported in Section 3.2: 5

1. single SRV discharge,
2. asymmetric discharge from two adjacent lines,
3. ADS discharge,
4. simultaneous actuation of all valves, and
5. sequential actuation of all valves.

It should be recognized that several (five) all valve discharge cases were studied before selecting the one (four above) that produced the largest load magnitudes. The all valve discharge cases and a brief description of each are provided in Table C.2-1. Thus, several mechanistic methods were used to determine five all valve load trials. By considering five trials which utilize worst-case mechanistic assumptions and conservative load methodology, it is judged that this procedure has produced

a conservative and appropriate load for design assessment of SRV Case 4 referenced above.

C.2.2 References

1. Mark II Dynamic Forcing Function Report, NEDO-21061, Rev. 2, General Electric. 5

2. Mark I Containment Program Analytical Model for Computing Transient Pressures and Forces in the Safety/Relief Valve Discharge Line, NEDE-23749-P, General Electric, February 1978.

TABLE C.2-1

IDENTIFICATION OF ALL-VALVE DISCHARGE CASES

1. Simultaneous Bubble Discharge. All 18 bubble pairs are identical and in phase. SRSS is used to simultaneously combine the effect of all the bubbles.

2. Symmetric Discharge. Simultaneous firing of all 18 valves used in Subsection 3.2.1.2 analysis. The bubble pairs are all unique and are not in phase. The effect of each bubble pair is combined by the SRSS method and each line's effect is then added linearly.

3. Ganged Sequential Discharge. All 18 lines are discharged in accordance with their given pressure relief setpoints for a linear RPV pressure transient. The maximum anticipated RPV pressure ramp rate of 136.4 psi/sec is used. The bubble pairs are all unique and out of phase. The effects of the bubbles are combined as in (2) above. 5

4. Continuous Sequential Discharge. All 18 lines are discharged in accordance with 18 different relief setpoints which could occur due to setpoint drift. The "drift" is assumed to cause all 18 setpoints to be equally spaced (in pressure) over the duration of SRV discharge. A linear RPV pressure transient is used. The maximum anticipated RPV pressure ramp rate of 136.4 psi/sec is used. The bubble pairs are all unique and out of phase. Their effects are combined as in (2) above.

5. Resonant Sequential Symmetric Discharge. All 18 lines are discharged in accordance with their given pressure relief setpoints for a linear RPV pressure transient. This case is reported in Subsection 3.2.1.2.2. These setpoints are equally spaced in pressure. The period

of oscillation of the first bubble pair in the pool is
determined. Then, the RPV pressure ramp rate is chosen
such that the period between actuation of adjacent relief
setpoints equals the oscillation period of the bubbles
in the pool. In this manner, an effort is made to cause
the discharge of subsequent relief valves to be in "resonance"
with the bubbles in the suppression pool. Variations 5
of the pressure ramp rate or value setpoint will generally
result in bubbles further out of phase since these variables
have been chosen within an allowable range to be as closely
phased as possible. The effects of bubble pairs are combined
as in (2) above.

C.3 ACCEPTANCE CRITERION III.A.1

C.3.1 LOCA Water Jet Loads

The NRC Lead Plant Acceptance Criteria required LOCA water jet loads to include the effects of a spherical vortex of fluid traveling with the jet front predicted by the Moody jet model (Reference 1). This procedure is expected to yield conservative result because the Moody model predicts jet penetrations much greater than those observed in tests.

In response to Criteria III.A.1, the LOCA water jet loads have been reassessed by several methods. The first is essentially the Acceptance Criteria III.A.1, incorporating a modification to the Moody methodology to overcome mathematical difficulties. The second is an adaptation of the method described by Abramovich and Solan (Reference 2). This method
conforms to the intent of the Acceptance Criteria, but describes 5
the vortex motion by applying conservation of momentum rather than using the Moody model. A final method that has been examined on a preliminary basis is the ring vortex model which is proposed by the Mark II Generic Program.

The NRC Acceptance Criteria utilizing the Moody jet model results in a vortex with a motion described by a locus of points. These points are found by tracking a number of constant velocity particles exiting from the downcomer and locating the points where a particle is overtaken by the one exiting after it. This calculation is easily done for a jet with constant acceleration, but causes difficulties when applied to a jet of increasing acceleration. When the Moody method is rigorously applied, depending upon the coordinate system chosen, the jet is predicted to reverse and move back to the vent or time as the jet front reverses. This result is unacceptable.

An alternate method has been applied which resolves these problems while conforming to the intent of the original NRC Acceptance Criteria. If the jet front position and velocity is described at any time by the particle having traveled the farthest, the jet motion is well behaved until the jet is terminated. High accelerations are experienced near the end of the transient that are overly conservative.

After vent clearing the vortex motion can be calculated assuming it continues through the pool. The water jet is, in fact, dissipated in the turbulence caused by flow of air into the pool. Calculations show that, until vent clearing, LOCA water jet loads on submerged structures in the La Salle suppression pool are negligible (less than 10% of design values). Higher loads are calculated on the quencher arms if the vortex is allowed to continue until it impacts the quencher arm. However, these loads are also within the design capability of the quencher. The calculations conservatively used direct jet 5
impingement on the quencher arms (the arms are offset in the actual plant), and no interchange of mass between the jet and pool. The vortex was considered a rigid sphere in determination of the drag load which retards its motion.

The second method is similar to that described above but uses a different method to describe the vortex motion. Following Abramovich and Solan (Reference 2), the motion and size of the vortex may be described assuming that momentum and mass are conserved as the jet forms the vortex. Momentum is lost only through drag on the fluid sphere.

The resulting motion of the vortex is similar to that calculated previously, but without the unrealistic high accelerations noted above. The loads are lower throughout the transient. This result is again conservative because interaction between the vortex and pool (other than rigid body drag) has been ignored.

The Mark II Generic Program has proposed a ring vortex model of the LOCA water jet. Preliminary results indicate this model predicts existing experimental data (Reference 3) well and will result in lower loads than the methods described above.

Based on the above evaluations, it is judged that for La Salle the LOCA water jet loads have been evaluated in accordance with the intent of the NRC criteria. As indicated, additional evaluations were done which demonstrate the conservatism of this evaluations. The results of these evaluations were that the S/RV quencher loads, were negligible relative to the controlling quencher design loads.

C.3.2 <u>References</u> 5

1. "Analytical Model for Liquid Jet Properties for Predicting Forces on Rigid Submerged Structures" NEDE-21472, September 1977.

2. S. Abramovich and A. Solan, "The Initial Development of a Submerged Laminar Round Jet". Journal Fluid Mechanics, 1978, Vol. 59, part 4, pp. 791-801.

3. "Mark I Containment Program 1/4 Scale Test Report Loads on Submerged Structures Due to LOCA Air Bubbles and Water Jets "NEDE-23817-P, September 1978.

D.0 FURTHER ANALYSES

D.1 FLUID STRUCTURE INTERACTION (FSI)

D.1.1 Original FSI Considerations

The primary consideration at the time of the subm.ttal of the DAR was to make a conservative assessment of the plant capability to carry additional loads due to pool dynamics by using conservative loads in readily available structural analysis models and to report the assessment and plant modifications to the NRC as expeditiously as possible. Therefore, when the containment structure was originally assessed for pool dynamic loads the effect of possible interaction between the rigid suppression pool wall and the fluid contained in the pool was neglected as small enough to be covered by other conservatisms obtained in the assessment. 5

This conclusion is justified because:

a. Conservative pool dynamic loads were used in the assessment.

b. Forces induced in the structures by pool dynamic loads are small compared to the governing design loads which include the effects of earthquake and design accident pressure.

These conservatisms in the design assessment coupled with the available reserve margin was judged to cover the approximation involved in neglecting the FSI effects.

D.1.2 Generic FSI Study

As part of the Mark II containment program, Burns & Roe analyzed for pool dynamic loads three typical Mark II containment pool

walls with and without fluid to estimate the approximation involved in neglecting FSI effects in structural analysis for pool dynamic loads. Details of this study are presented in Reference 1.

Table D.1-1 summarizes the results of the Burns & Roe study applicable to the La Salle containment wall. The ratio of the maximum positive/negative wall displacements with and without fluid was used in this study as a measure of the influence of fluid structure interaction on the structural response.

The study showed that:

a. FSI effects are present to varied degrees and that their magnitude is not always negligible.

b. FSI does not necessarily amplify the wall responses 5
but also tends to reduce the responses, depending on the dynamic characteristics of the structure and the loading.

c. Plant unique FSI analyses will be necessary to determine FSI effects accurately.

D.1.3 <u>La Salle FSI Analysis</u>

A plant unique FSI analysis has been performed to determine the actual FSI-inclusive forces and moments.

Figure D.1-1 shows the refined structural analysis model which includes the containment wall, the basemat, the founding soil, and the fluid in the pool. The fluid is simulated by fluid finite elements described in Reference 2. Dynamic analyses for SRV and LOCA chugging loads were performed using this plant unique FSI analysis model and the analysis procedures

described in Subsections 5.1.1 and 5.1.2 of the Closure Report. The resulting forces and moments in the structure include the actual plant unique FSI effects. FSI does not necessarily amplify the wall forces, but also tends to reduce them, depending on the dynamic characteristics of the structure and the loading. These forces and moments are combined with other loads in the load combinations defined in Table 4.1-1 using the conservative ABS method, even though the SRSS method is more appropriate.

The margin factors for the containment wall and basemat including the actual FSI effects are presented in Tables D.1-2 through D.1-9. It can be seen that the containment structure has the capability to sustain the pool dynamic loads including the attendant FSI effects. 5

D.1.4 References

1. "Evaluation of Fluid Structure Interaction Effects on BWR Mark II Containment Structures," NEDE-21936-P.

2. A. J. Kalinowski, "Transmission of Shock Waves into Submerged Fluid Filled Vessels," ASME Conference on FSI Phenomena in Pressure Vessel and Piping Systems, TVP-TB-026, 1977.

3. K. T. Patton, Tables of Hydrodynamic Mass Factors for Translational Motion, ASME Paper No. 65-WA/UNT-2; 1965.

TABLE D.1-1

FSI AMPLIFICATION FACTOR

LOADING	RESPONSE	FSI AMPLIFICATION FACTOR (REFERENCE 1)
SRV 5 Hz.	Max. + ve Displ.	0.993
	Max. - ve Displ.	0.982
SRV 8 Hz.	Max. + ve Displ.	1.084
	Max. - ve Displ.	1.347
SRV 11 Hz.	Max. + ve Displ.	1.066
	Max. - ve Displ.	1.747
Chugging	Max. + ve Displ.	1.299
	Max. - ve Displ.	0.902

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$$\text{FSI Amplification factor} = \frac{\text{Max. response with fluid}}{\text{Max. response without fluid}}$$

TABLE D.1-2

MARGIN TABLE FOR BASE MAT FOR ALL VALVES DISCHARGE

(With Plant Unique FSI)

LOAD COMBINATION EQUATION* \ STRESS COMPONENT	REINFORCING STEEL		CONCRETE		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	2.03	2	4.72	2	1.05	2
2	2.27	2	5.23	2	1.30	2
3	1.33	2	3.01	2	1.01	2
4	NA	NA	NA	NA	NA	NA
4a	NA	NA	NA	NA	NA	NA
5	NA	NA	NA	NA	NA	NA
5a	NA	NA	NA	NA	NA	NA
6	1.30	2	2.91	2	1.04	2
7	NA	NA	NA	NA	NA	NA
7a	NA	NA	NA	NA	NA	NA

NOTES: *Refer to Table 4.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figures 4.1-9 & 4.1-10
NA = Not Applicable

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TABLE D.1-3

MARGIN TABLE FOR BASE MAT FOR 2 VALVES DISCHARGE

(With Plant Unique FSI)

LOAD COMBINATION EQUATION* \ STRESS COMPONENT	REINFORCING STEEL		CONCRETE		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	2.61	2	6.07	2	1.35	2
2	2.92	2	6.73	2	1.68	2
3	1.71	2	3.87	2	1.27	2
4	2.07	2	5.05	2	2.16	2
4a	NA	NA	NA	NA	NA	NA
5	1.58	2	3.59	2	1.64	2
5a	NA	NA	NA	NA	NA	NA
6	1.67	2	3.75	2	1.32	2
7	1.39	2	3.28	2	1.50	2
7a	NA	NA	NA	NA	NA	NA

NOTES: *Refer to Table 4.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figures 4.1-9 & 4.1-10
NA = Not Applicable

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TABLE D.1-4

MARGIN TABLE FOR BASE MAT FOR ADS VALVES DISCHARGE

(With Plant Unique FSI)

LOAD COMBINATION EQUATION* \ STRESS COMPONENT	REINFORCING STEEL		CONCRETE		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	NA	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA
4	1.61	2	3.92	2	1.68	2
4a	NA	NA	NA	NA	NA	NA
5	1.23	2	2.79	2	1.27	2
5a	NA	NA	NA	NA	NA	NA
6	NA	NA	NA	NA	NA	NA
7	1.08	2	2.55	2	1.16	2
7a	NA	NA	NA	NA	NA	NA

NOTES:
*Refer to Table 4.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figures 4.1-9 & 4.1-10
NA = Not Applicable

TABLE D.1-5

MARGIN TABLE FOR BASE MAT FOR LOCA PLUS SINGLE SRV

(With Plant Unique FSI)

LOAD COMBINATION EQUATION* \ STRESS COMPONENT	REINFORCING STEEL		CONCRETE		SHEAR		
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION	
1	NA	NA	NA	NA	NA	NA	
2	NA	NA	NA	NA	NA	NA	
3	NA	NA	NA	NA	NA	NA	
4	NA	NA	NA	NA	NA	NA	
4a	1.55	2	3.39	2	1.79	2	5
5	NA	NA	NA	NA	NA	NA	
5a	1.58	2	2.59	2	1.30	2	
6	NA	NA	NA	NA	NA	NA	
7	NA	NA	NA	NA	NA	NA	
7a	1.58	2	2.43	2	1.19	2	

NOTES: *Refer to Table 4.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figures 4.1-9 & 4.1-10
NA = Not Applicable

TABLE D.1-6

MARGIN TABLE FOR CONTAINMENT FOR ALL VALVES DISCHARGE

(With Plant Unique FSI)

LOAD COMBINATION EQUATION* \ STRESS COMPONENT	REINFORCING STEEL		CONCRETE		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	4.33	1	2.17	1	1.23	13
2	4.16	1	2.02	1	1.26	13
3	2.44	14	1.82	1	1.26	13
4	NA	NA	NA	NA	NA	NA
4a	NA	NA	NA	NA	NA	NA
5	NA	NA	NA	NA	NA	NA
5a	NA	NA	NA	NA	NA	NA
6	2.16	14	1.83	1	1.27	13
7	NA	NA	NA	NA	NA	NA
7a	NA	NA	NA	NA	NA	NA

NOTES: *Refer to Table 4.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figures 4.1-9 & 4.1-10
NA = Not Applicable

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TABLE D.1-7

MARGIN TABLE FOR CONTAINMENT FOR 2 VALVES DISCHARGE

(With Plant Unique FSI)

LOAD COMBINATION EQUATION* \ STRESS COMPONENT	REINFORCING STEEL		CONCRETE		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	6.22	1	3.12	1	1.23	13
2	5.97	1	2.90	1	1.26	13
3	3.50	14	2.61	1	1.26	13
4	2.69	14	3.42	1	1.28	13
4a	NA	NA	NA	NA	NA	NA
5	1.75	14	3.04	1	1.28	13
5a	NA	NA	NA	NA	NA	NA
6	3.10	14	2.63	1	1.27	13
7	1.52	14	2.97	1	1.28	13
7a	NA	NA	NA	NA	NA	NA

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NOTES: *Refer to Table 4.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figures 4.1-9 & 4.1-10
NA = Not Applicable

TABLE D.1-8

MARGIN TABLE FOR CONTAINMENT FOR ADS VALVES DISCHARGE

(With Plant Unique FSI)

LOAD COMBINATION EQUATION* \ STRESS COMPONENT	REINFORCING STEEL		CONCRETE		SHEAR		
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION	
1	NA	NA	NA	NA	NA	NA	
2	NA	NA	NA	NA	NA	NA	
3	NA	NA	NA	NA	NA	NA	
4	1.87	14	2.38	1	1.28	13	5
4a	NA	NA	NA	NA	NA	NA	
5	1.22	14	2.12	1	1.28	13	
5a	NA	NA	NA	NA	NA	NA	
6	NA	NA	NA	NA	NA	NA	
7	1.06	14	2.07	1	1.28	13	
7a	NA	NA	NA	NA	NA	NA	

NOTES: *Refer to Table 4.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figures 4.1-9 & 4.1-10
NA = Not Applicable

TABLE D.1-9

MARGIN TABLE FOR CONTAINMENT FOR LOCA PLUS SINGLE SRV

(With Plant Unique FSI)

LOAD COMBINATION EQUATION* \ STRESS COMPONENT	REINFORCING STEEL		CONCRETE		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	NA	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA
4	NA	NA	NA	NA	NA	NA
4a	1.57	14	2.59	1	1.52	8
5	NA	NA	NA	NA	NA	NA
5a	1.08	14	2.66	1	1.50	8
6	NA	NA	NA	NA	NA	NA
7	NA	NA	NA	NA	NA	NA
7a	1.00	14	2.6	1	1.54	8

NOTES: *Refer to Table 4.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figures 4.1-9 & 4.1-10
NA = Not Applicable

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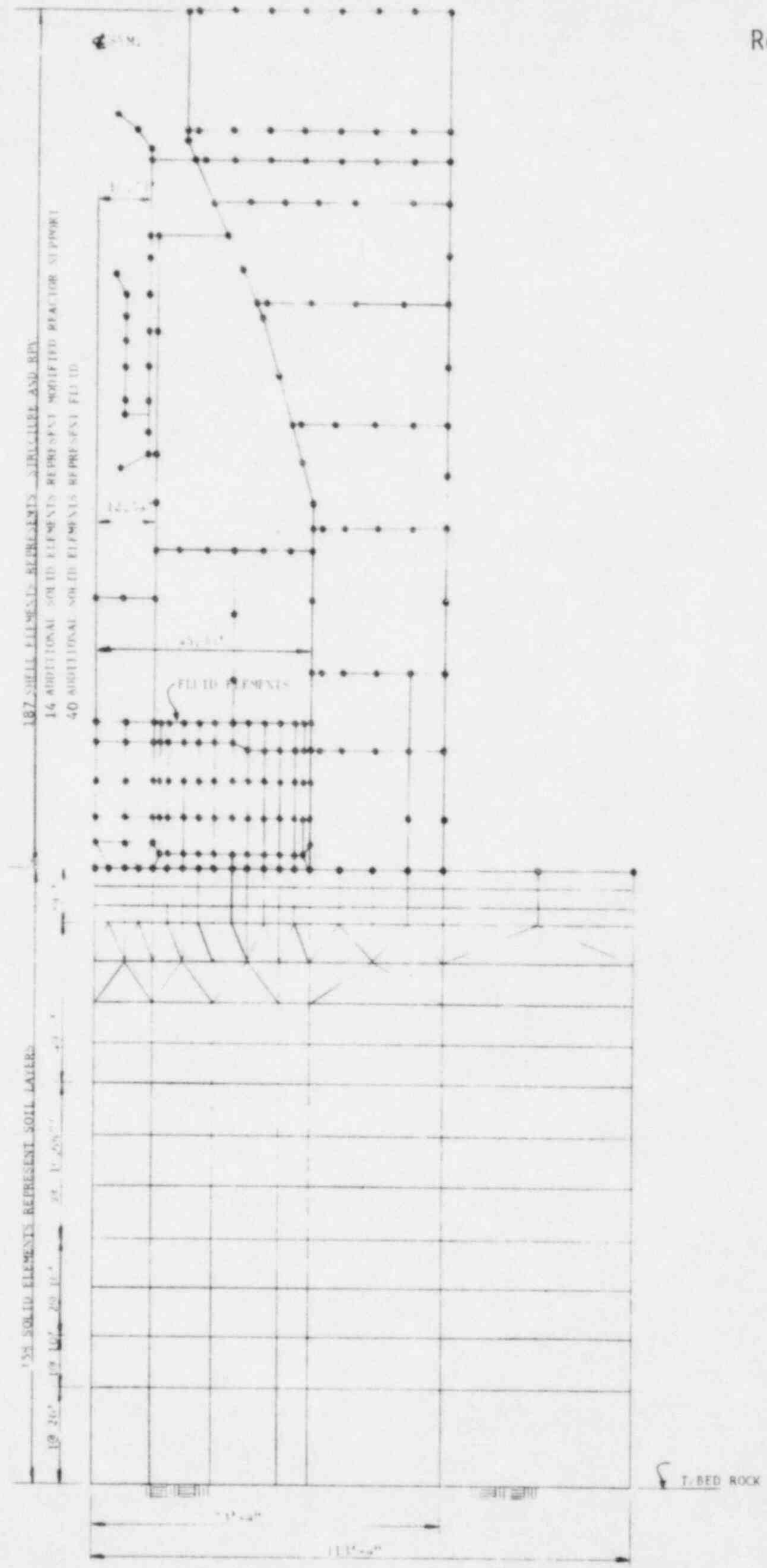

LA SALLE COUNTY STATION

MARK II DESIGN ASSESSMENT REPORT

FIGURE D.1-1

LA SALLE FSI ANALYSIS MODEL