CAROLINA POWER & LIGHT COMPANY
SHEARON HARRIS NUCLEAR POWER PLANT
CONTAINMENT RECIRCULATION SUMP EVALUATION

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CAROLINA POWER AND LIGHT COMPANY

SHEARON HARRIS NUCLEAR POWER PLANT PROJECT

CONTAINMENT RECIRCULATION SUMP EVALUATION

I. PURPOSE

The purpose of this report is to document the adequacy of the Shearon Harris Nuclear Power Plant Containment Recirculation Sump. This study has been performed by Carolina Power and Light Company using the guidelines provided in the Proposed Resolution to Generic Safety Issue A-43 described in NUREG-0869 Rev. 1 (Reference 1). The evaluation considers insulation debris generated inside the reactor containment building during a loss of coolant accident (LOCA), and the effects of sump screen debris blockage on the RHR and Containment Spray pump performance.

II. INTRODUCTION

The Shearon Harris containment recirculation sumps are designed to provide an adequate supply of water to the Containment Spray (CT) and Residual Heat Removal (RHR) pumps during the recirculation mode of the Emergency Core Cooling System (ECCS). Per guidelines contained in NUREG-0869 R1, a plant specific debris blockage evaluation has been performed to show that the insulation debris resulting from primary system pipe breaks will not degrade the performance of the containment sumps or the RHR and CT pumps. This conclusion is based on the sump and containment layout, the types of insulation used, and the post-LOCA recirculation requirements.

III. SUMP AND CONTAINMENT BUILDING LAYOUT

There are two completely independent containment recirculation sumps located 90 degrees apart in the annulus formed by the secondary shield wall and the containment liner. Each sump contains the suction intakes for one RHR pump and one CT pump. The sumps are enclosed by a concrete structure with a solid steel roof. Six (6) 4' x 3'-10" vertical openings in each sump facing the secondary shield wall admit flow. Each opening houses a convoluted perforated fine inner screen (plate), having 1/8" diameter holes with an open flow area of 26.5 Ft^2. These fine inner screens are protected by an outer trash rack with 1 1/2" square openings. Protecting the sumps from high density debris is an 18" high curb around the structure. The floor immediately in front of the curb is sloped gradually down and away from the sump (aproximately 3" from the highest to the lowest point). Figures 1, 2, and 3 describe the sump structure, screens, and curb. The sumps are protected from the effects of postulated primary system pipe breaks (e.g., Jet Impingement and Pipe Whip) by the personnel (2'-6" thick, 8' high) and secondary shield walls (4' thick) and the concrete structure (18" thick) housing the sumps (See Figures 3, 4 and 5). Following a LOCA, the floor in the containment will be filled with water. Water drawn from the recirculation sumps will be returned to the containment via the containment spray headers and through the break in the Reactor Coolant System. The water that will be returned inside the secondary shield wall will reach the sumps primarily via twenty (20) 18" x 18" drain openings and three (3) 3' wide door size openings in the personnel shield wall and twenty-one (21) 4' x 12' high openings in the secondary shield wall. The openings are distributed along the perimeter of the walls (see Figures 4 and 5). It should be noted that this water will not be admitted to the sump until the water level exceeds the height of the curb.

IV. PIPE BREAKS AND JET EXPANSION MODEL

This study is based upon debris which results from the dynamic effects of postulated high energy pipe breaks. The design basis locations and types of postulated pipe breaks considered in this study are consistent with those provided in FSAR Section 3.6.2 (Reference 2). Pipe breaks which do not result in ECCS actuation or long term recirculation are not considered for this study. Furthermore, arbitrary intermediate breaks are not considered in this study consistent with the NRC acceptance of "elimination of arbitrary intermediate breaks" (Reference 3).

Jet impingement forces are the dominant insulation debris generator. Other contributors, such as pipe whip and resultant impact, are considered to be of secondary importance (NUREG/CR-2791) (Reference 4). The three-region jet/debris generation model is shown on Figure 6. Region I is where extremely high levels of destruction would occur due to the very high break jet pressures. Region II is a zone where high levels of destruction are possible (depending upon the insulation used, methods of attachment, etc). Region III is a zone where destruction will likely be dislodgement of insulation in the as-fabricated mode, or as modules. For conservatism, total destruction of all insulation in Regions I and II is assumed.

V. TYPE AND LOCATION OF INSULATION INSIDE CONTAINMENT

The table below summarizes the types of insulation used in the Shearon Harris Nuclear Power Plant inside containment and the piping and components for which they are used:

TYPE	MANUFACTURER	APPLICATION
Reflective Metallic: MIRROR	Diamond Power Specialty Company	BOP Pipes/Components NSSS Components
Reflective Metallic: TRANSCO	Transco	NSSS Pipes/Components
FIBERGLASS (Jacketed)	Knauf or Certainteed	Tubing for S.G. Reference Legs.
MIN-K (Jacketed)	Johns-Manville	Pressurizer Loop Seals and Selected Pipe Whip Restraints
MICROTHERM (Encapsulated)	Transco	Reactor Vessel beltline region from the nozzles down approximately 48 in.
RICORAD (Neutron Shielding Encapsulated)	The Richardson Company	Reactor Vessel beltline region from the nozzles down approximately 48 in.

V. TYPE AND LOCATION OF INSULATION INSIDE CONTAINMENT (Continued)

Reflective Metallic Insulation represents over 95% of the total insulation used inside the reactor containment building. This is an all-metallic insulation design based on the concept of utilizing a series of highly reflective foils to retard heat transfer. SHNPP utilizes TRANSCO's Reflective Insulation and Diamond Power's Reflective Mirror Insulation on most NSSS and non-NSSS piping and components requiring insulation. At present Carolina Power and Light Company is considering the use of MIN-K insulation for the Pressurizer Safety Relief Valve loop seals (6" insulation thickness on 6" line) and the Power Operated Relief Valve loop seals (3" insulation thickness on 3" line). Therefore, this insulation is considered in this study. MIN-K is an insulating material formed from fibrous media and very fine particulate matter. The beltline region of the reactor vessel from the nozzles down approximately 48 inches is covered with a heavy sandwich design consisting of Microtherm thermal insulation and Ricorad neutron shielding encapsulated in stainless steel. Jacketed fiberglass insulation is used for the 1/2" tubing on the steam generator reference legs. This insulation will be provided by either Certainteed Corporation or Knauf Fiberglass. Each is made of jacketed fiberglass cylindrical sections.

VI. LIMITING BREAK CASE

The breaks evaluated in this report are limited to those which result in ECCS actuation and associated long term recirculation. By inspection the following systems were chosen for detailed evaluation:

1) Reactor Coolant Loop 2
2) Pressurizer Safety and Relief Lines
3) Pressurizer Surge Line

VI. LIMITING BREAK CASE (Continued)

Loop 2 was chosen because: a) it is close to the sumps, b) the pressurizer is unique to Loop 2, and c) the configuration of RC Loop branch piping and other insulated components in the vicinity of Loop 2 is typical to the piping and components on the other two Loops. Detailed sketches showing the jet/target interactions were produced to determine the quantity of affected insulation due to each postulated break. Considering such items as break size, jet/target orientation, location, and insulation targets affected, the following limiting cases for maximum reflective metallic and maximum MIN-K insulations were evaluated (the detailed sketches showed that the other types of insulation were not affected):

1) Reactor Coolant Loop 2 Hot Leg Break at the S.G. Nozzle.
2) Pressurizer SRV Inlet Line.

Interaction sketches showing the insulation affected for these two limiting cases are shown as examples on Figures 7 and 8.

VII. INSULATION DEBRIS EVALUATION

There are two methods by which LOCA-generated debris can be transported to the sump areas. The first method occurs during the short term blowdown phase when the jet force itself distributes the debris. The second method is by long term transportation which will occur during the recirculation phase when containment flow forces control the transport of debris.

VII. INSULATION DEBRIS EVALUATION (Continued)

A detailed review of the LOCA jet cones, the sump location, and containment building layout has shown that none of the jet cones generated insulation debris that could fall near the sumps and cause blockage. The only means by which debris generated by these LOCA jets could block the sumps is by escaping through the 18" x 18" drain openings on the personnel shield wall on the 221' floor elevation and the openings below the removable roof above the pressurizer. Each jet was investigated individually and in no case did the jet cones blow through the openings.

VIII. NEAR SUMP FLOW VELOCITY

The guidelines set forth in Section 3.3.6 in NUREG-0897 (Reference 5) states that long term insulation debris transport to the sump screens depends on the flow velocity. The results of testing performed on reflective metallic and fibrous type insulations (See NUREG-0897 Rev. 1, Section 3.3.5 and 3.3.6) revealed that the water velocities needed to initiate the motion of debris are on the order of 0.2 ft/sec for individual shreds, 0.5 to 0.7 ft/sec for individual small pieces (up to 4 inches on the side), and 0.9 to 1.5 ft/sec for individual large pieces (up to 2 feet on the side). See Tables 3.7 and 3.8 in NUREG-0897 Rev. 1.

VIII. <u>NEAR SUMP FLOW VELOCITY</u> (Continued)

Based on this criteria, the following sump velocity calculation was performed:

In the region near the sump, the flow velocity can be calculated by dividing the total recirculation flow by the total flow path area:

$$V = \frac{Q}{A}$$

Where,

Q = Recirculation Flow

(ECCS + Containment Spray Pump Flows)

= 3891 gpm + 2110 gpm

= 6001 gpm

= 13.37 ft^3/sec

A = Flow Path Area

(Just Before the 18" Curb)

= Length of Curb x Minimum Submergence

= 44.5 ft x 2.96 ft

= 131.7 ft^2

Therefore,

$$V = \frac{13.37 \frac{ft^3}{sec}}{131.7\ ft^2}$$

$$V = 0.10 \frac{ft}{sec}$$

The flow rates used in the above calculation are the maximum expected flow rates during the recirculation mode considering conservative assumptions such as 0 psig RC Loop pressure.

The flow area is calculated using free flow area available near the sump and the minimum water level in the containment. The minimum water level in the containment is calculated using the minimum water volume available from Refueling Water Storage Tank (RWST) during injection mode. For conservatism, additional water that may be available from the RWST during switchover mode, or from the accumulator tanks and R. C. Loops has not been included.

This velocity of 0.1 ft/sec in above calculation is less than the velocity required to transport any reflective metallic or fibrous insulation debris. Therefore, a detailed evaluation of total insulation quantity destroyed is not required and is not presented.

IX. SPECIFIC INSULATION EVALUATION

The following provides an evaluation for each type of insulation used on the Shearon Harris Plant:

A. REFLECTIVE METALLIC INSULATION (RMI)

As noted earlier, the majority of insulation inside containment is RMI. Although jet cones can destroy or dislodge insulation, none of the insulation will reach the sump screens because of the following:

- Metal material from the insulation will sink. (See Reference 5 and Section 2.b of Reference 6)
- Near sump flow velocity (0.10 ft/sec) is less than the minimum velocity (0.2 ft/sec) required to transport RMI. (See Reference 6 and Table 3.7 of Reference 5)
- The 18" high curb wall around the sump will prevent insulation debris from reaching the sump.

B. FIBERGLASS INSULATION

Fiberglass insulation is used only on the steam generator reference legs. None of the jet cones will hit this insulation. Therefore, none of the fiberglass insulation will be transported to the sump.

C. MIN-K INSULATION

A very limited quantity of MIN-K insulation is used for the pressurizer loop seal piping and for selected pipe whip restraints. None of this insulation will be transported to the sumps because of the following:

- Insulation will sink when wet.
- Near sump flow velocity (0.1 ft/sec) is less than the minimum velocity (0.2 ft/sec) required to transport fibrous insulation.
- 18" high curb wall around the sump will prevent insulation debris from reaching the sump.

D. RICORAD AND MICROTHERM INSULATION

This insulation is used only on limited on portions of the Reactor Vessel inside the primary shield wall. None of this insulation will be transported to the sump.

X. NPSH MARGIN

During the long-term recirculation cooling mode, the containment recirculation sump design must assure that sufficient water is provided to the RHR and Containment Spray Systems such that pump performance is not impaired; i.e., provides adequate net positive suction head (NPSH). The table below compares the required NPSH with the available NPSH for the CT and RHR pumps:

	REQUIRED NPSH (FT)	AVAILABLE NPSH (FT)	NPSH MARGIN
Containment Spray Pump	12 @ 2110 gpm	27.23* @ 2.96' min containment water level above containment floor EL. 221'.	15.23 Ft or 117%
ECCS (RHR) Pump	17 @ 3891 gpm	26.16* @ 2.96' min containment water level above containment floor EL. 221'.	9.12 Ft or 53%

* Based on the model test of the SHNPP sumps (See Reference 8), the inlet loss coefficient, K, for RHR and CT inlets are, 0.69 and 0.54, respectively. These coefficients translate to a pressure drop of less than 0.005 ft which is negligible when compared to available NPSH. Therefore, this factor was not included in the available NPSH calculation.

XI. CONCLUSION

This evaluation has shown the following:

- None of the postulated pipe breaks generated short term debris that could fall near the sump and block the screens.
- Although the postulated pipe breaks may generate long term debris, the insulation will not be transported to the sump due to the low sump water velocities.
- Since debris will not reach the sump, there will be no appreciable pressure drop through the screens. The pressure drop through the clean screens is insignificant.
- ECCS and CT pump NPSH requirements will not be impaired.
- Sufficient NPSH margin exists in the SHNPP ECCS and CT pumps.
- The Containment Recirculation Sump performance will not be degraded due to postulated pipe breaks.
- The existing Containment Recirculation Sump Design is technically sound.

REFERENCES

(1) NUREG-0869 Rev.-1, 'USI A-43 Regulatory Analysis", May 30, 1984.

(2) Final Safety analysis Report - Shearon Harris Nuclear Power Plant Unit-1 - Docket No. 50-400.

(3) Letter from Thomas M. Novak, Assistant Director for Licensing Division of Licensing Nuclear Regulatory Commission, to Mr. E. E. Utley, Executive Vice-President CP&L "Arbitrary Intermediate pipe Breaks - SHNPP Unit-1" dated August 15, 1985.

(4) NUREG/CR-2791 "Methodology for Evaluation of Insulation Debris Effects", September 1982.

(5) NUREG-0897 Rev.-1 "Containment Emergency Sump Performance", March 30, 1984.

(6) NUREG/CR-3616 "Transport and Screen Blockage Characteristics of Reflective Metallic Insulation Materials", January 1984.

(7) NUREG/CR-2982 "Buoyancy, Transport, and Head Loss of Fibrous Reactor Insulation", November 1982.

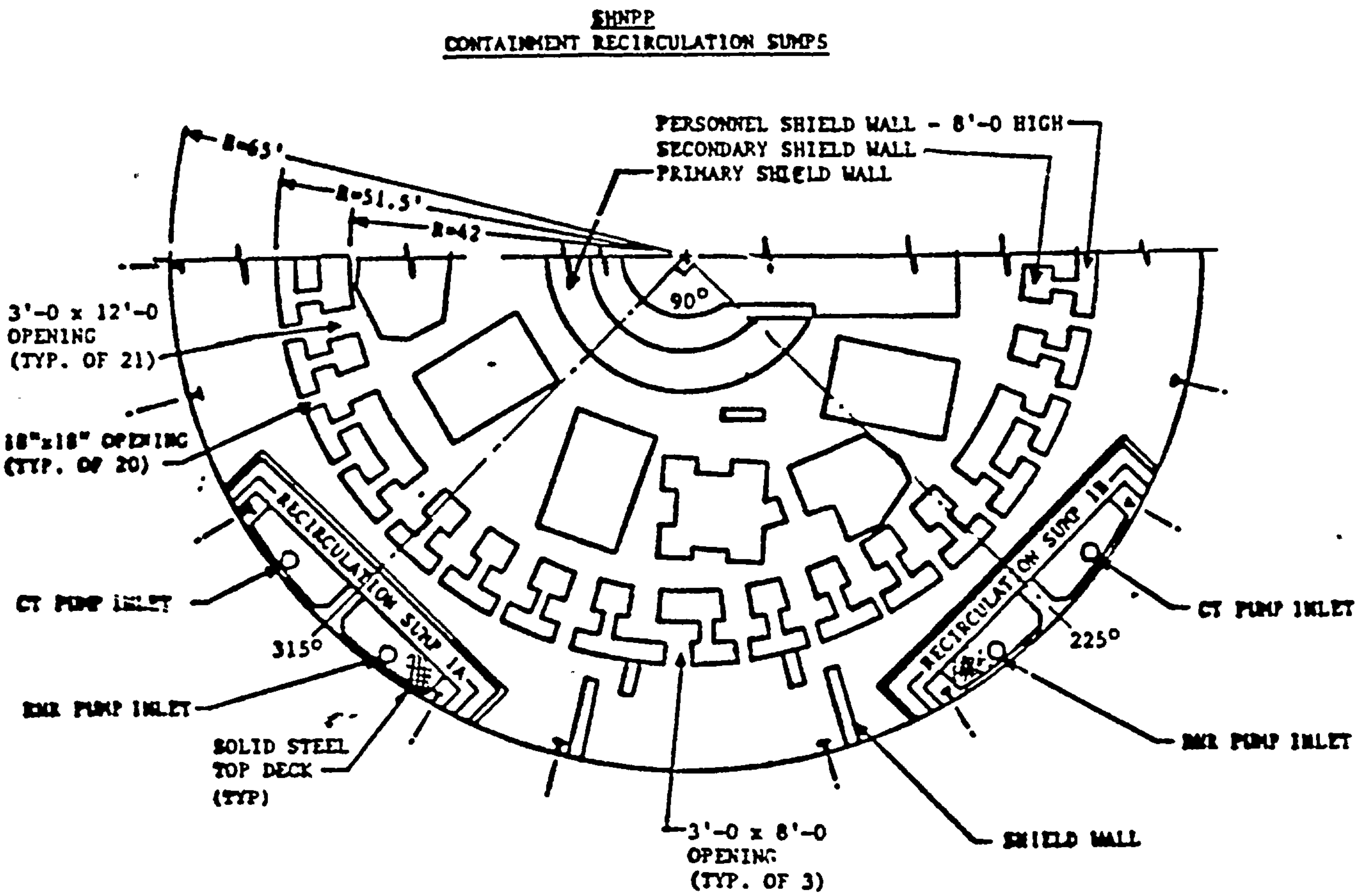
(8) Hydraulic model test report "Reactor Containment Recirculation Sump Evaluation - SHNPP" Alden Research Laboratory WPI, September 1984.

APPENDIX A

FIGURES

CAROLINA POWER & LIGHT COMPANY
SHEARON HARRIS NUCLEAR POWER PLANT
CONTAINMENT RECIRCULATION SUMP EVALUATION

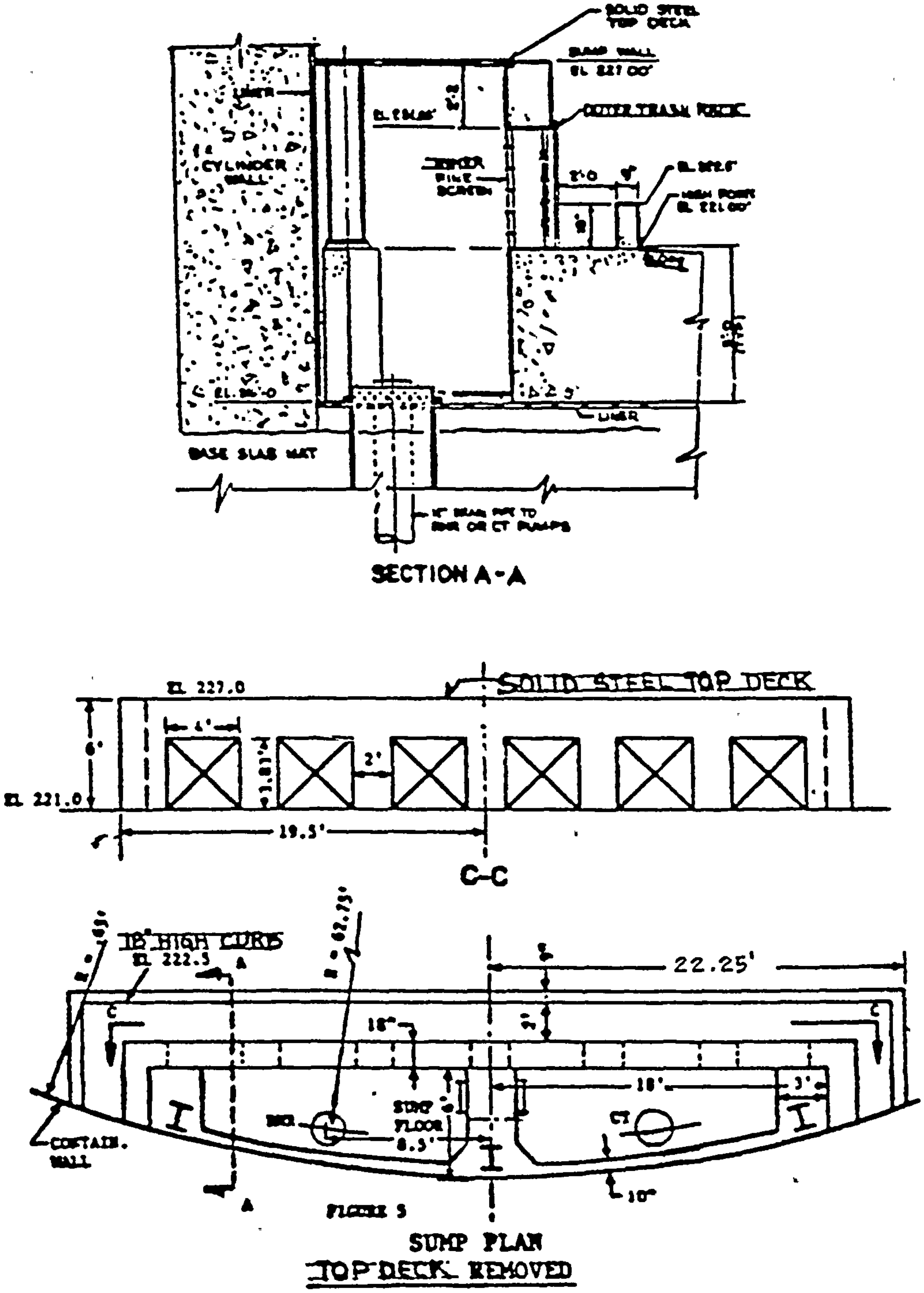
FIGURE 1



CONTAINMENT RECIRCULATION SUMPS

CAROLINA POWER & LIGHT COMPANY
SHEARON HARRIS NUCLEAR POWER PLANT
CONTAINMENT RECIRCULATION SUMP EVALUATION

FIGURE 2



CONTAINMENT RECIRCULATION SUMP DETAIL

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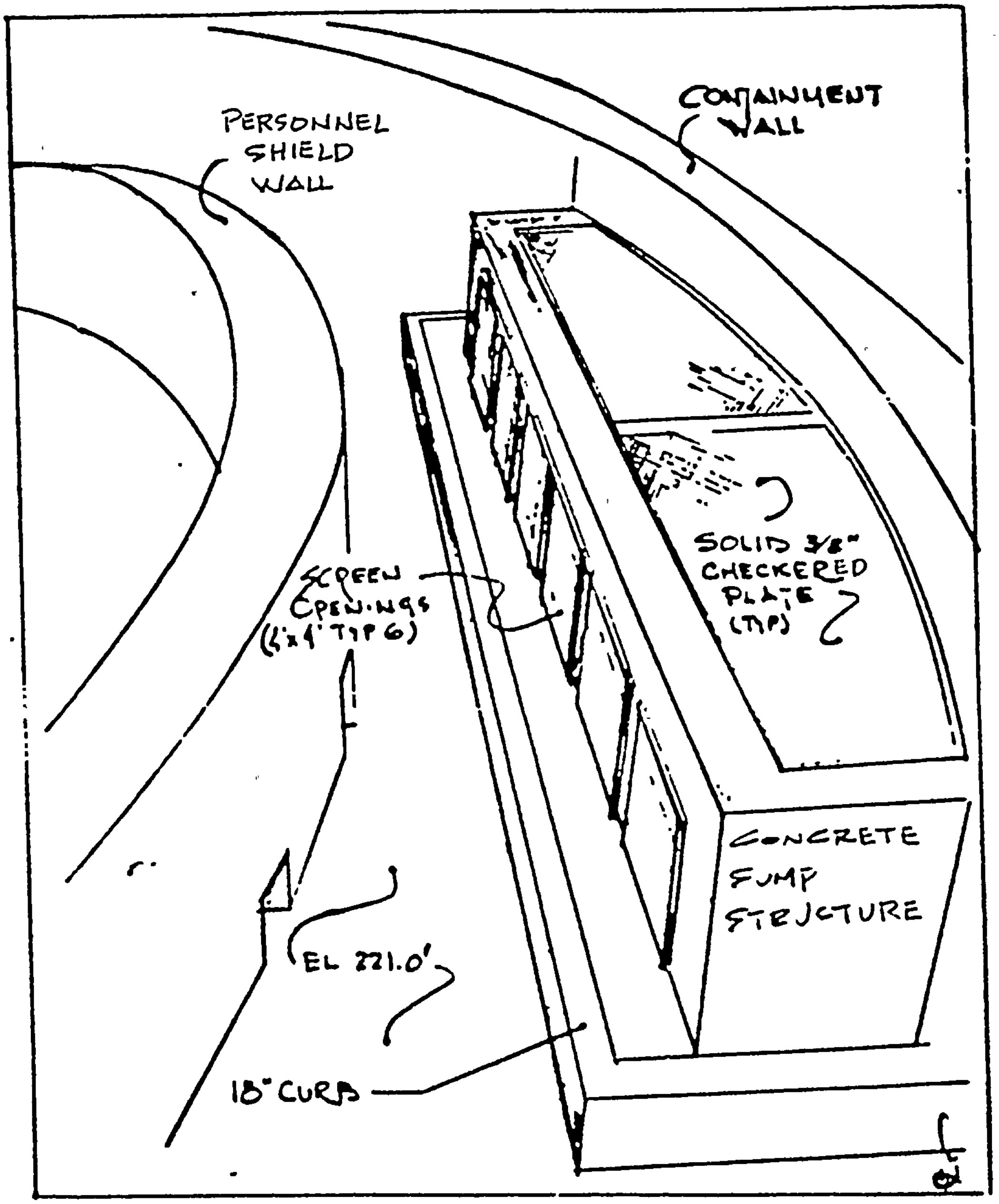
SHEARON HARRIS NUCLEAR POWER PLANT
CONTAINMENT RECIRCULATION SUMP EVALUATION

FIGURE 3



SHEARON HARRIS NUCLEAR POWER PLANT

CONTAINMENT RECIRCULATION SUMPS

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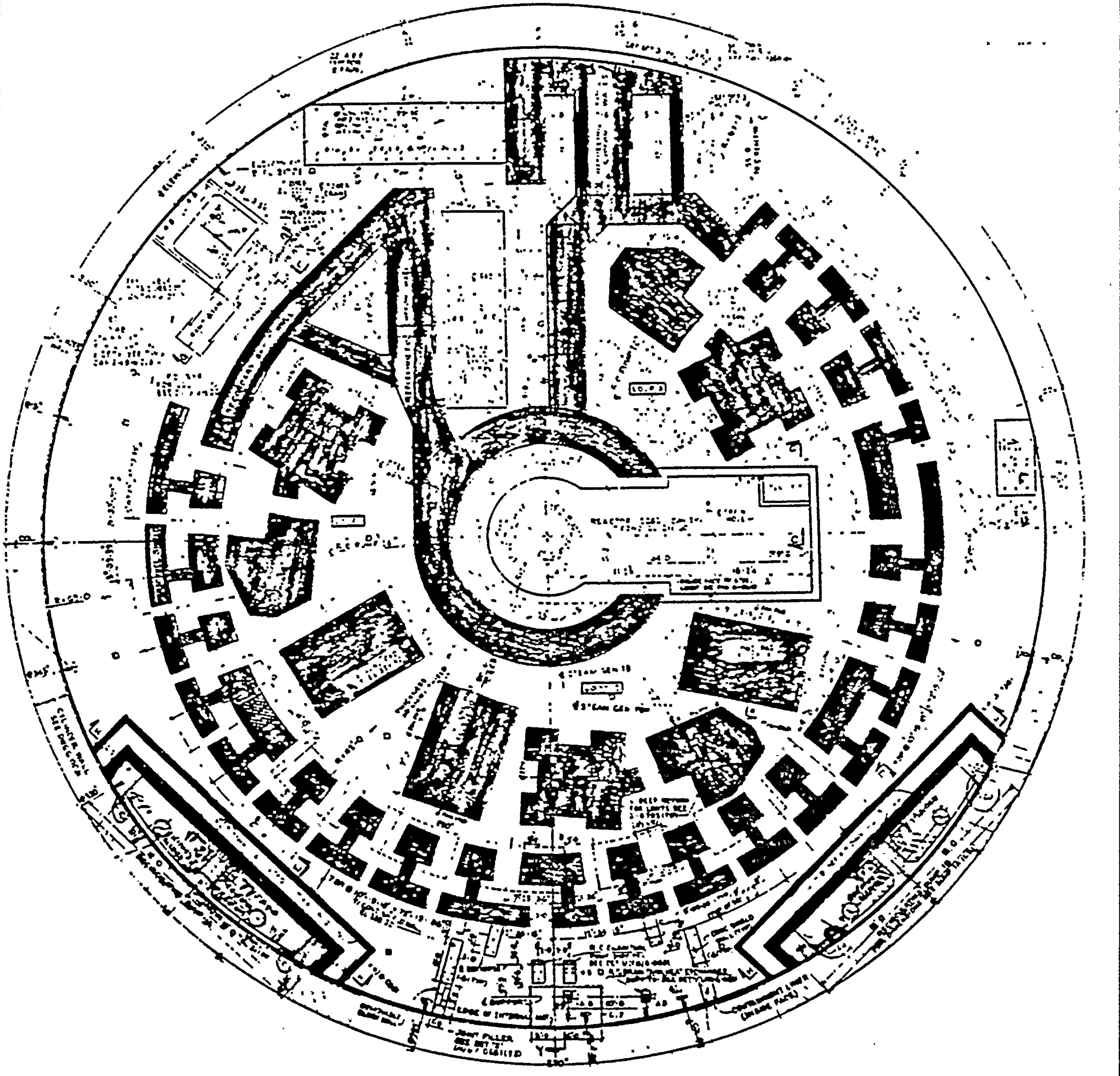
SHEARON HARRIS NUCLEAR POWER PLANT
CONTAINMENT RECIRCULATION SUMP EVALUATION

FIGURE 4
(See FSAR Figure 1.2.2-3 for Better Resolution)



CONTAINMENT BUILDING
PLAN AT EL. 221'

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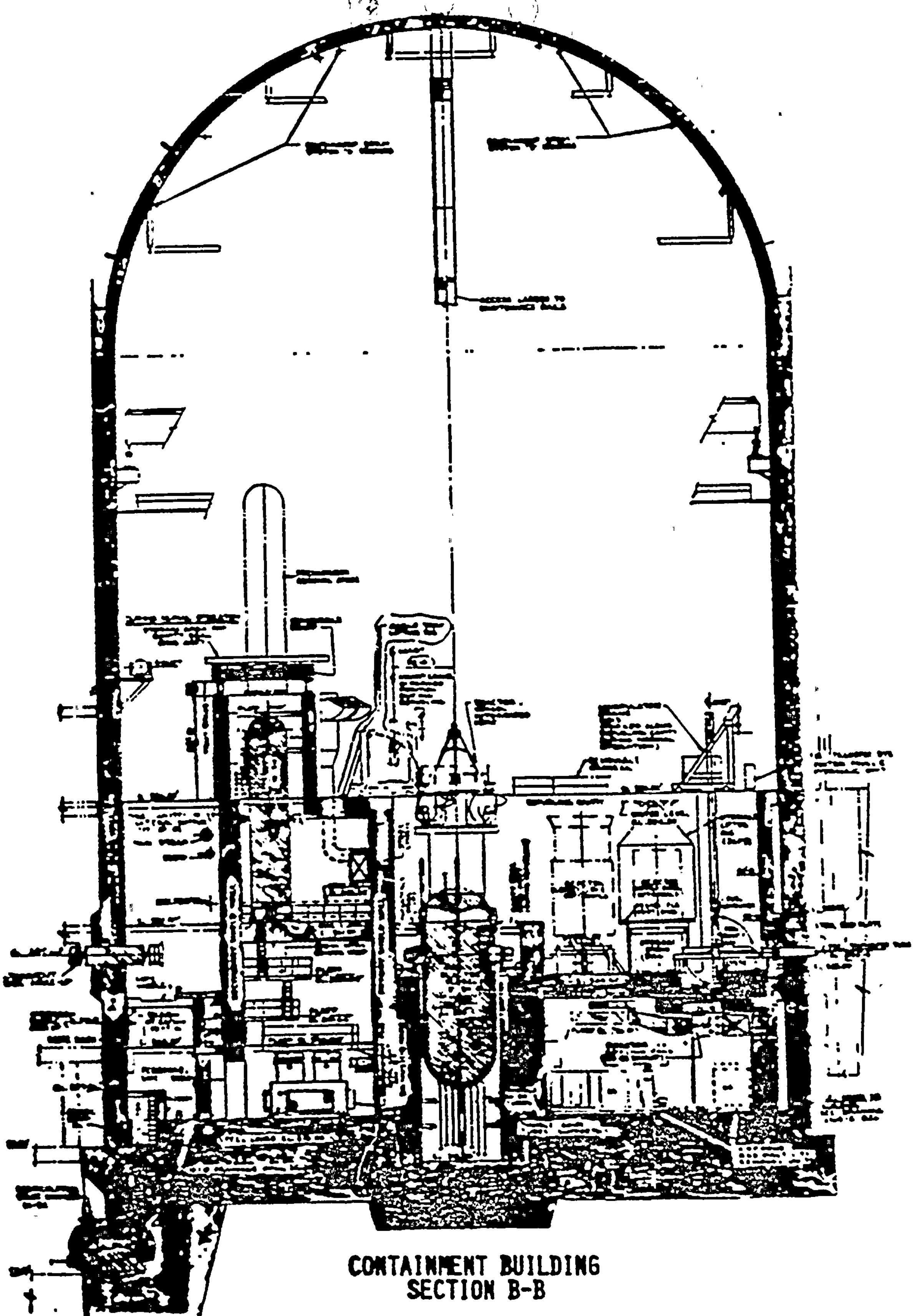
CONTAINMENT RECIRCULATION SUMP EVALUATION

FIGURE 5
(See FSAR Figure 1.2.2-11 for Better Resolution)



CONTAINMENT BUILDING
SECTION B-B

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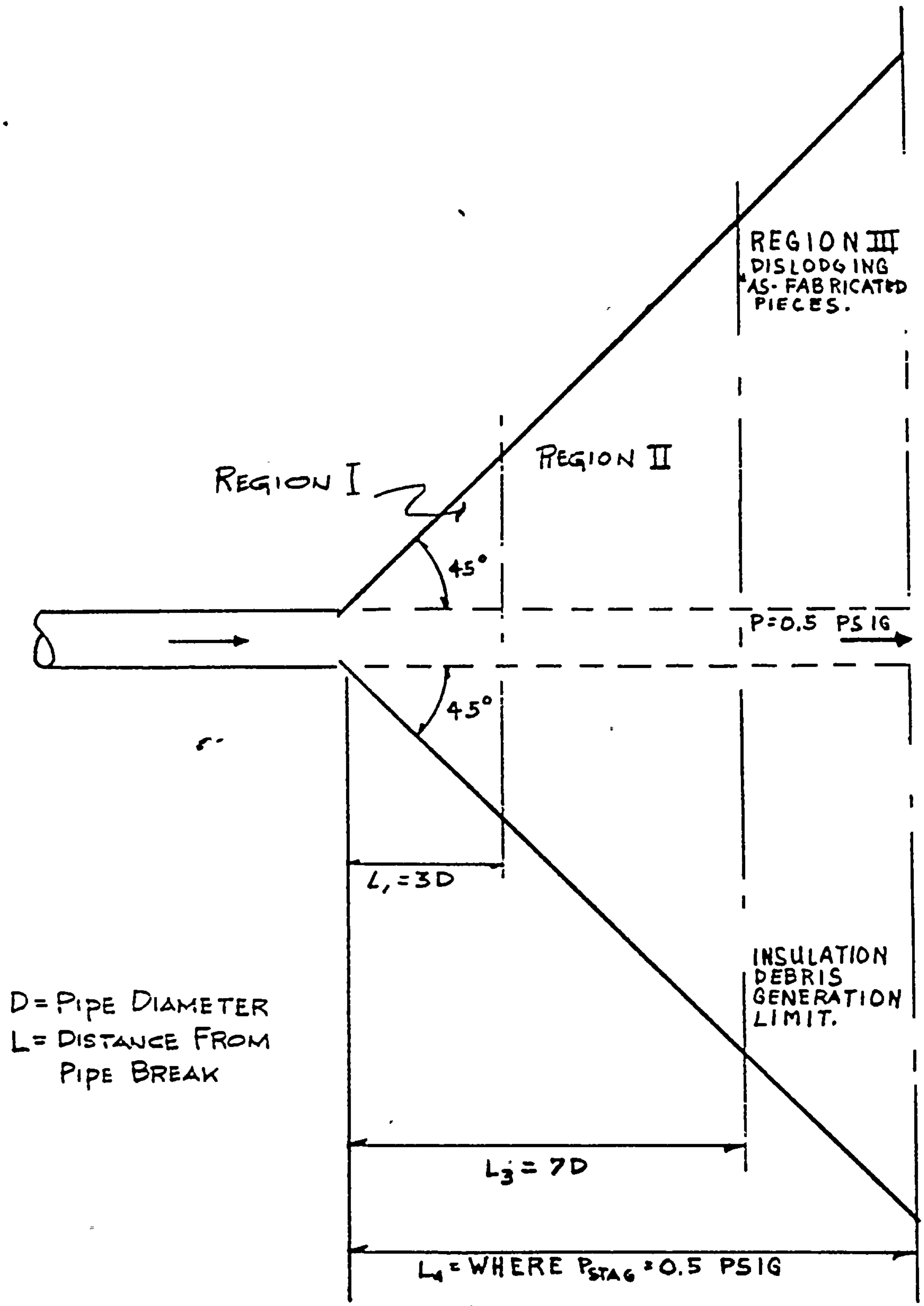
CONTAINMENT RECIRCULATION SUMP EVALUATION

FIGURE 6



JET EXPANSION MODEL

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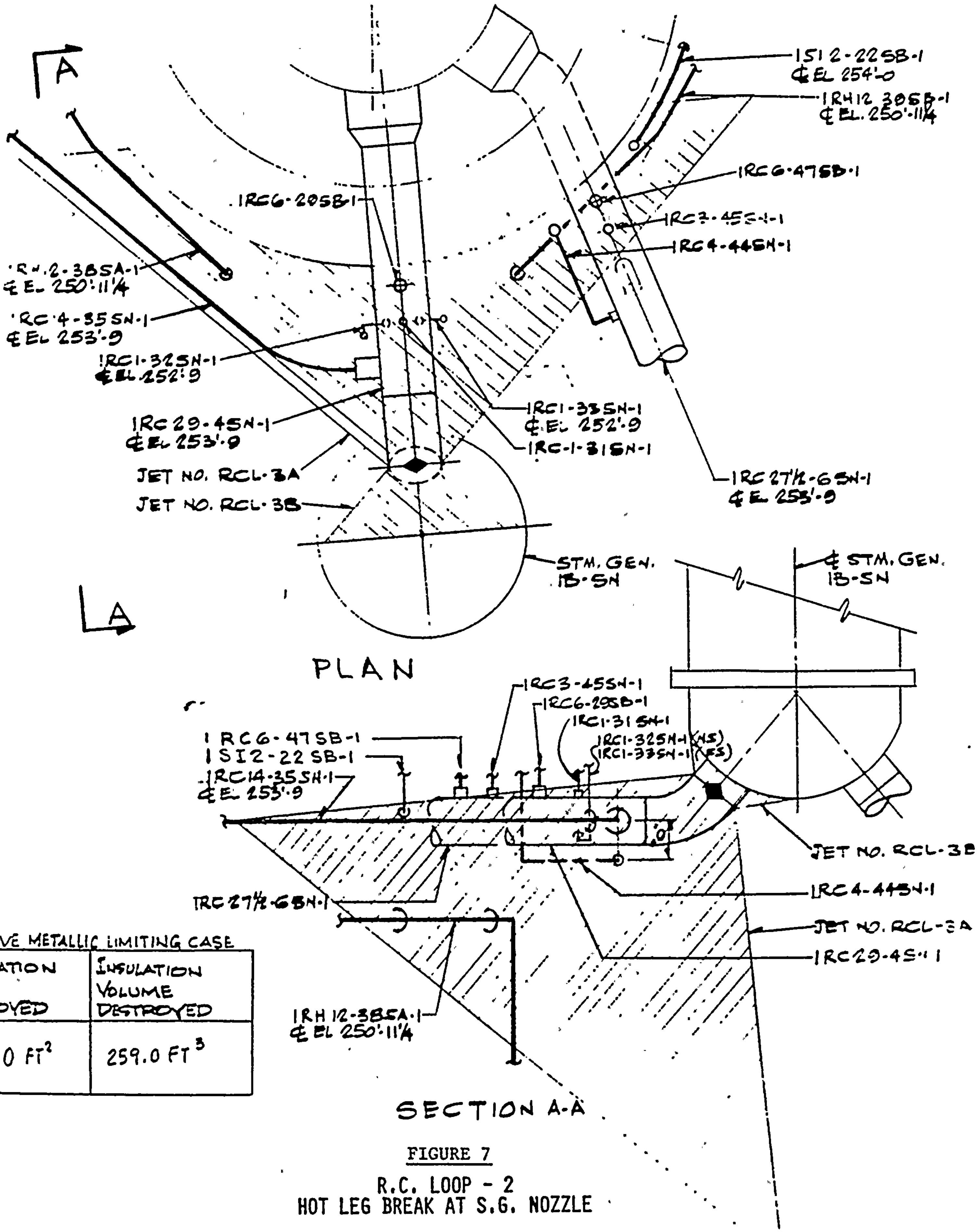
CONTAINMENT RECIRCULATION SUMP EVALUATION



REFLECTIVE METALLIC LIMITING CASE

INSULATION AREA DESTROYED	INSULATION VOLUME DESTROYED
967.0 FT^2	259.0 FT^3

FIGURE 7

R.C. LOOP - 2
HOT LEG BREAK AT S.G. NOZZLE

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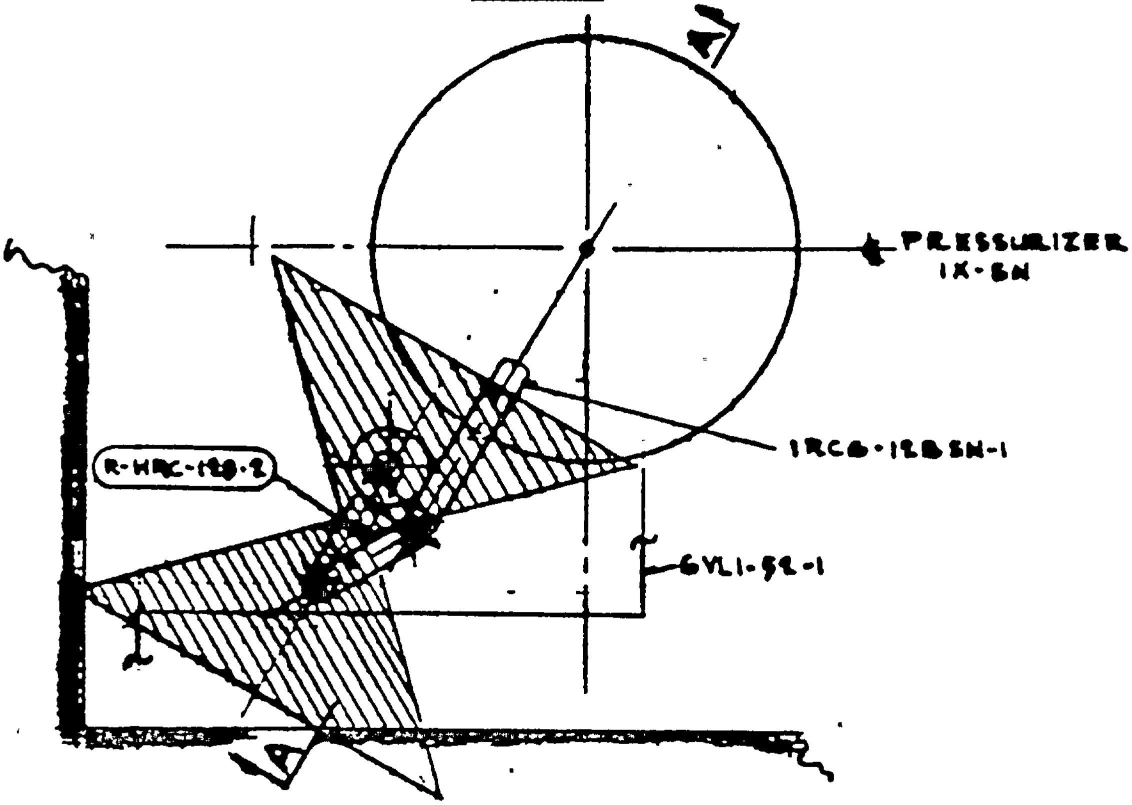
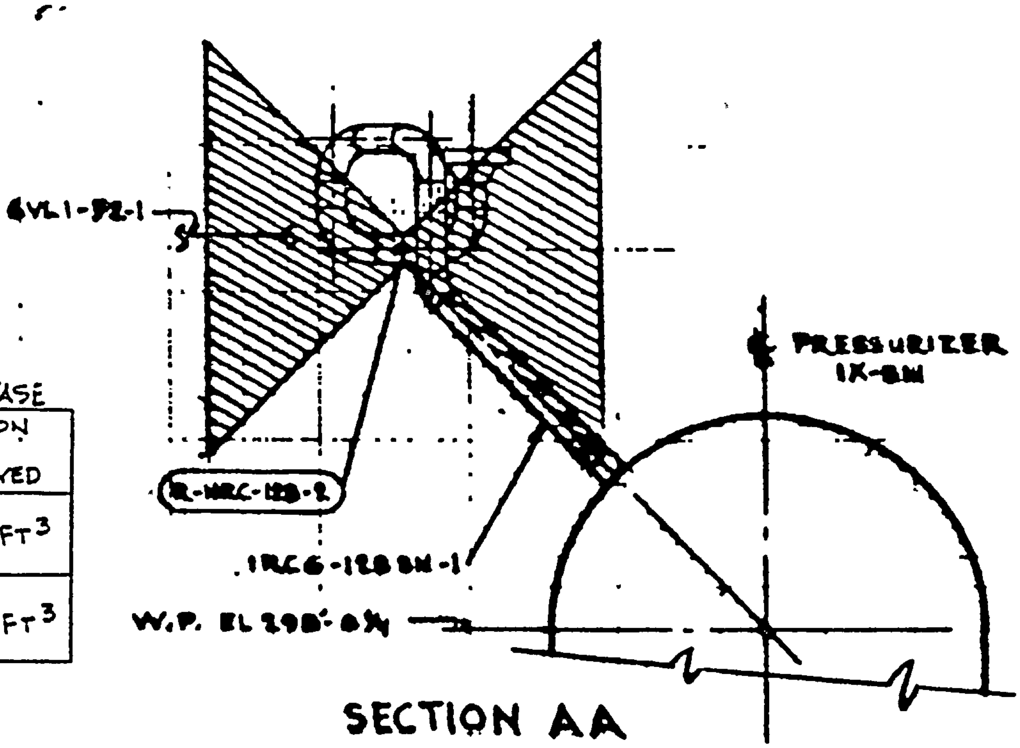
CONTAINMENT RECIRCULATION SUMP EVALUATION

FIGURE 8



PLAN



SECTION AA

MIN-K INSULATION LIMITING CASE

TYPE	INSULATION AREA DESTROYED	ISULATION VOLUME DESTROYED
MIN-K	29.5 FT^2	15.0 FT^3
REFLECTIVE METALLIC	26.0 FT^2	8.0 FT^3

PRESSURIZER SRV INLET PIPING
LOOP SEAL PIPE BREAK

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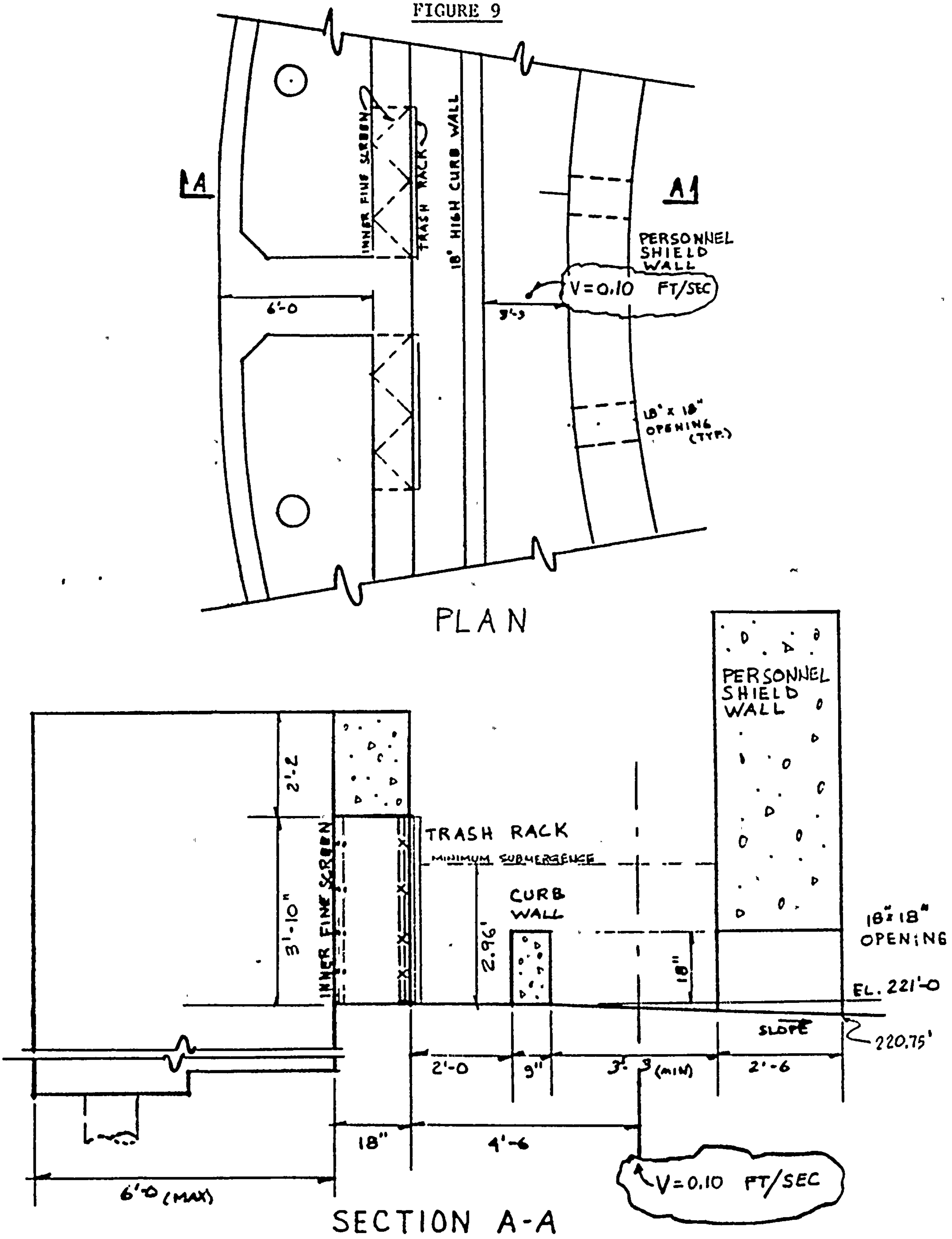
CONTAINMENT RECIRCULATION SUMP EVALUATION

FIGURE 9



CONTAINMENT BUILDING NEAR
SUMP FLOW VELOCITY

ENCLOSURE 2

ATTENDANCE LIST

Shearon Harris Containment Sump Design Meeting
September 18, 1985

NAME	AFFILIATION
Bart Buckley	NRC
Jim Milhoan	NRC
Chang Li	NRC
John Huang	CP&L
Roger Stewart	Ebasco
Michael G. Gagliardi	Ebasco
Dean Shah	Ebasco
David C. McCarthy	CP&L