OYSTER CREEK
SAPHIRE 5.0 DATABASE
IRRAS-LEVEL LOAD
March 20, 1995

OYSTER CREEK NUCLEAR GENERATING STATION

SAPHIRE 5.0
PROBABILISTIC RISK ASSESSMENT DATABASE
FOR INTERNALLY GENERATED EVENTS

IRRAS-LEVEL LOAD

Revision 0

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March 20, 1995

This database was developed in accordance with the requirements of the NRC's Plant Database Development for SAPHIRE project; FIN W6241.

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FACT SHEET

WE CAN USE YOUR HELP

If problems, errors, or discrepancies are encountered when using this database please call Mr. R. C. Robinson of the U. S. Nuclear Regulatory Commission's (NRC's) Office of Regulatory Research at (301)415-7839, or Mr. R. D. Fowler or Mr. W. J. Galyean at the Idaho National Engineering Laboratory (INEL) at (208)526-1257 and (208)526-0627, respectively. We are interested in any response you can provide, whether positive or negative.

BACKUP THE ORIGINAL DATABASE

A backup copy of this database should be created and protected to prevent unintentional destruction or modification of the data and results initially loaded and generated.

THE SAPHIRE CODES

If a problem is encountered with the SAPHIRE codes, the problem should be referred to Mr. R. C. Robinson at the NRC at (301)415-7839 or Mr. K. D. Russell at the INEL (208)526-9592.

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1. INTRODUCTION

Data and information reported in the Oyster Creek Nuclear Generating Station (OCNGS) probabilistic risk assessment (PRA) (Reference 1) were used to create a database for use with the Systems Analysis Programs for Hands-on Integrated Reliability Evaluations (SAPHIRE) codes. Only that data and information for internally generated events were loaded. Initially, a cutset-level load database was developed for the OCNGS plant. This cutset-level database was upgraded to create this "full-scope" Integrated Reliability and Risk Analysis System (IRRAS) level database. Both databases were developed in support of the Nuclear Regulatory Commission's (NRC's) Plant Database Development for SAPHIRE project; FIN W6241 (Reference 2).

The OCNGS PRA was developed using the new PLG methodology, which does not include the event trees and fault trees in graphical form. PLG's RISKMAN program was used to develop the PRA. In comparison with other databases developed for use with the SAPHIRE codes, the OCNGS "full-scope" IRRAS-level load is one of the more difficult and challenging databases developed. Significant effort was required to convert the new PLG methodology for use with SAPHIRE, especially the development of event tree graphics. The new event tree free-format rule-based feature recently added to the SAPHIRE codes aided in completing this database. Using this new feature, "if-then-else" rules were created for assigning the proper split-fraction for each top event in any given sequence.

As stated, the OCNGS database is a "full-scope" IRRAS-level load, with the exception that the fault tree models are not included. The fault tree models are not included because the number of fault tree gates exceeds the 10K limit inherent to the version of the SAPHIRE codes used to develop the OCNGS database. Because the system frequencies cannot be generated from fault tree models, the split-fraction results reported in the PRA were manually loaded into the SAPHIRE Models and Results Database (MAR-D) system.

Those event tree models included in the SAPHIRE database were developed based on the PRA-related event sequence diagrams, logic block diagrams, and split-fraction assignment rules. After the event tree models were created and loaded into MAR-D, logic rules were developed to assign the proper split-fractions to the event tree top events.

The point estimate core damage frequency (CDF) reported in the OCNGS PRA is 3.69E-06 per year. The total CDF is primarily composed of those accident sequences above a cutoff of 1.0E-09. However, sequences for each initiating event were quantified using a truncation value of 1.00E-13. Using the same 1.00E-13 truncation in IRRAS, the frequency for the same accident sequences is 3.681E-06, which is in good agreement with the PRA.

Results for only 100 dominant accident sequences are reported in the PRA. The combined frequency for these 100 sequences is 3.03E-06. The frequency generated by IRRAS for these same 100 sequences is also 3.030E-06. Again, this shows that the IRRAS results are in very good agreement with the PRA. However, the results for some specific sequences do vary. Refer to Section 4.0 for a comparison of the results.

Although the OCNGS IRRAS-level database was initially created using Version 5.07 of the SAPHIRE codes, the database has been verified to correctly function using Version 5.12. The SAPHIRE codes are a suite of four programs that include (1) IRRAS, (2) MAR-D, (3) the System Analysis and Risk Assessment (SARA) system, and (4) the Fault Tree, Event Tree, and Piping and Instrumentation (FEP) Editors. These programs are briefly discussed in Section 2.

This letter report provides (1) an overview of the dominant accident sequence results reported in the OCNGS PRA (Reference 1), (2) an overview of the SAPHIRE-related data, information, and results, (3) a discussion of the pertinent PRA-related problems, discrepancies, inconsistencies, or errors encountered, (4) any data modifications or changes required to properly load the PRA-related data and information into MAR-D, and (5) any special requirements or procedures for using the database. It is not intended that this report includes detailed procedures for developing the database or for using the SAPHIRE codes.

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This report includes:

- An introduction (Section 1)
- A brief outline of the SAPHIRE codes (Section 2)
- An overview of the PRA-related information (Section 3)
- A comparison of the results reported in the PRA with the results generated using IRRAS (Section 4)
- A brief overview of the quality assurance and internal independent reviews (Section 5)
- The details for any PRA related problems, discrepancies, inconsistencies, or errors identified during the database development process. This section also includes any special procedures used to load the data into MAR-D (Section 6).
- Special guidance for using the database (Section 7)
- References (Section 8)

1.1 Purpose

The purpose of the NRC's Plant Database Development for SAPHIRE project is to load plant-specific PRA data and information into the MAR-D system to support the NRC's analytical needs. Such analytical needs may include additional safety studies, cost/benefit analyses, and an efficient means to evaluate generic safety issues (GSIs).

1.2 Objective

The objectives of the Plant Database Development Project are: (1) to provide databases containing PRA information from selected PRAs in a format suitable for NRC applications, and (2) to provide guidance and assistance to other programs (as necessary) regarding the use of this data.

The nuclear power plant PRA data and information are collected and loaded into the MAR-D database system in accordance with the requirements specified in Reference 2. The requirements are designed to help ensure the PRA results can be reasonably reproduced using the SAPHIRE codes. It is not part of the program objective to review the PRAs for completeness, accuracy, or validity. However, the database development process does provide some checks of the data. Any errors, discrepancies, inconsistencies, or concerns identified during the database development process were resolved when possible. Problems were resolved in close cooperation with persons involved in the development of the PRA, or persons knowledgeable in PRA analyses.

1.3 Scope

The Oyster Creek SAPHIRE 5.0 database is limited to those data, information, and results associated with internally generated events. Data, information, and results for externally generated events are not included. As has been typical with developing IRRAS-level databases for other plants, flood-related events are not included.

This database is an IRRAS-level load; in an IRRAS-level load the dominant accident sequence results are typically generated using linked event tree and fault tree models. However, because the number of fault tree gates exceeds the 10K limit inherent to the version of the SAPHIRE codes used to develop the database, no fault tree models are included.

2. THE SAPHIRE CODES

The Systems Analysis Programs for Hands-on Integrated Reliability Evaluations (SAPHIRE) refers to a set of several microcomputer programs developed to create and analyze PRAs (primarily for nuclear power plants). The Oyster Creek database was developed using Version 5.0 of SAPHIRE. The SAPHIRE programs are briefly described below. More detailed information is provided in the noted references.

2.1 Integrated Reliability and Risk Analysis System (IRRAS)

The Integrated Reliability and Risk Analysis System (IRRAS) (Reference 3) is a state-of-the-art, microcomputer-based PRA model development and analysis tool to address key nuclear plant safety issues. IRRAS is an integrated software tool that gives the user the ability to create and analyze fault trees and accident sequences using a microcomputer. This program provides functions that range from graphical fault tree construction to cutset generation and quantification to report generation.

An IRRAS tutorial manual (Reference 4) is also provided. This manual involves a series of lessons provided to guide the user through basic steps common to most analyses performed with IRRAS. The tutorial is divided into two major sections: Basic and additional features. The basic section contains lessons that lead the student through development of a very simple problem in IRRAS, highlighting the program's most basic features. The additional features section contains lessons that expand on basic analysis features of IRRAS 5.0.

2.2 System Analysis and Risk Assessment (SARA)

The System Analysis and Risk Assessment (SARA) program (Reference 5) is used to analyze the safety issues of a "family" (i.e., a power plant, a manufacturing facility, any facility on which a PRA might be performed). The SARA database contains PRA data primarily for the dominant accident sequences of a "family" and descriptive information about the "family" including event trees, fault trees, and system diagrams. The number of facility databases that can be accessed is limited only by the amount of disk storage available. To simulate changes to "family" systems, SARA users change the failure rates of initiating and basic events and/or modify the structure of the cutsets that make up the event trees, fault trees, and systems. The user then evaluates the effects of these changes through the recalculation of the resultant accident sequence probabilities and importance measures. The results are displayed in tables and graphs that may be printed for reports.

A preliminary version of the SARA program was completed in August 1985 and has undergone several updates in response to user suggestions and to maintain compatibility with the other SAPHIRE programs. Version 5.0 of SARA provides the same capability as earlier versions and adds to the ability to process unlimited cutsets; display fire, flood, and seismic data; and perform more powerful cutset editing.

A SARA tutorial manual (Reference 6) is also provided. This manual involves a series of lessons provided to guide the user through some basic steps common to most analyses performed with SARA. The example problems presented in the lessons build on one another, and in combination, lead the user through all aspects of SARA sensitivity analysis capabilities.

2.3 Models and Results Database (MAR-D)

The primary function of the Models and Results Database (MAR-D) system (Reference 7) is to create a data repository for completed PRAs and Individual Plant Examinations (PRAs) by providing input, conversion, and output capabilities for data used by IRRAS, SARA, SETS, and FRANTIC software. As PRAs are submitted to the NRC for review, MAR-D can be used to convert the models and results from the study for use with IRRAS and SARA. Then, these data can be easily accessed by future studies and will be in a form that will enhance the analysis process. The MAR-D reference manual provides an overview of the functions available within MAR-D and step-by-step operating instructions.

2.4 Fault Tree, Event Tree, and P&ID (FEP) Editors

The Fault Tree, Event Tree, and Piping and Instrumentation Diagram Editors (FEP) (Reference 8) allow the user to graphically build and edit fault trees, event trees, and piping & instrumentation diagrams (P&ID). The software is designed to enable the independent use of the graphical-based editors found in the IRRAS system. This reference manual provides a screen-by-screen guide to the entire FEP System.

3. PROBABILISTIC RISK ASSESSMENT DATA AND INFORMATION

3.1 Oyster Creek PRA Background Information

The Oyster Creek plant is a General Electric boiling water reactor (BWR-2) with a MARK 1 type containment. The plant has a net capacity of 1,935 MWt. The plant began commercial power generation on December 23, 1969. Oyster Creek, which is operated by the GPU Nuclear Corporation (GPU), is located near the Atlantic Ocean about nine miles South of Toms River, New Jersey. Condenser cooling water, and cooling water for many plant auxiliaries, are drawn from Barnegat Bay through a canal following the south branch of Forked River. The water is then discharged through another canal following Oyster Creek back to the Bay.

3.2 Overview of the PRA Results

The OCNGS plant PRA was developed by a project team under the direction of GPU. Project team members consisted of persons from GPU and PLG, Incorporated. The PRA submittal contains a summary of the methods, results, and conclusions in compliance with the NRC request for information contained in Generic Letter 88-20. The PRA represents the design and operation of Oyster Creek as configured in 1989 along with the following planned 14R modifications:

1. An interconnection to the combustion turbine generators on Forked River sites to provide an alternate ac source

2. A hard-piped containment vent system

3. Provisions for an all manually initiated containment spray system

The plant model was developed using information collected on the integrated plant response to an initiating event. The information consisted of the following plant-specific analyses; Updated Final Safety Analysis Report (UFSAR), Technical Document Reports (TDRs), and various thermohydraulic calculations, and Transient Assessment Reports (TARS). This information, combined with plant abnormal response procedures, and the emergency operating procedures (EOPs), serve as the basis for the development of preliminary event sequence diagrams.

Plant initiating event and system dependence matrices were also developed. The matrices illustrate the dependence of plant systems, and for initiating events, the impacts of the initiator on plant systems. See Reference 1 for more detailed information.

3.2.1 Systems Analyzed

Twenty-five systems are analyzed in the OCNGS PRA. Where necessary, fault logic files were developed for these systems. Some of these fault logic files are extremely large (i.e., individual files with more than 700 gates).

- Isolation Condenser
- Turbine Trip and Bypass
- Alternate Current
- Direct Current
- Engineering Safety Features Actuation System
- Reactor Protection System
- Service Water
- Turbine Building Closed Cooling Water
- Main Steam Isolation
- Core Spray
- Containment Spray/Emergency Service Water
- Recirculation Pump Trip
- Condensate and Feedwater
- Main Condenser and Circulating Water
- Automatic Depressurization System
- Standby Liquid Control
- Primary Containment Isolation
- Standby Gas Treatment System
- Fire Protection Water
- Condensate Transfer
- Instrument Air
- Control Rod Drive Hydraulics
- Reactor Building Isolation
- Main Steam Relief
- Torus Vent

3.2.2 Event Tree Development, Quantification, and CDF Profile

The initiating events and descriptions used in the PRA are listed in Table 3.2.2-1. The OCNGS CDF profile by accident type is provided in Table 3.2.2-2. The top ten contributors are noted. Relative contribution of major initiating event categories to the total CDF is 87% due to general transients, 7% due to small LOCAs, and 6% due to large LOCAs.

Importance of independent failures of systems (event tree top events), and the percent contribution to the CDF, is displayed in Table 3.2.2-3. The percent contribution is a summation of the frequency of all sequences involving independent failure of the top event. It represents the percentage decrease in the CDF that would result if the top event failure rate could be made zero. The sum of all percentages is greater than 100% because more than one top event failure may occur in a given core damage sequence.

Table 3.2.2-1. OCNGS - Initiating Events.

Initiating Event	Description
GENERAL TRANSIENTS:	
RT	Reactor Trip
TT	Turbine Trip
EPRH	Turbine pressure control malfunction - sensing high (full bypass operation from full power)
EPRL	Turbine pressure control malfunction - sensing low (turbine trip without bypass)
CMSIV	MSIV closure
LOFW	Loss of feedwater
PLOFW	Low RPV water level trip (partial LOFW or level control system failure, sensing high level)
LOCW	Loss of circulating water
LOCV	Loss of condenser vacuum
LOIA	Loss of instrument air
LOIS	Loss of intake water to pump pit (due to sea grass clogging)
LOSP	Loss of offsite power (34.5kV failure with plant trip)
LOTB	Loss of TBCCW
LOFC	Feedwater control system failure (high RPV water level)
SMALL LOSS OF COOLANT ACCIDENTS:	
SAI	Small above core break inside containment (one safety valve open, discharging to drywell)
IEMRV	Inadvertent EMRV operation (one valve discharging to torus)
SBI	Small below core break inside containment (RWCU line break/recirc pump seal failure)
SBO	Interfacing system LOCA (unisolated RWCU break in Reactor Building)

Table 3.2.2-1. (Continued)

Initiating Event	Description
SAOIC	Small above core break outside containment (unisolated ICS tube rupture)
SAORB	Small steamline break in Reactor Building
SAOTB	Small steamline break in Turbine Building
<u>LARGE LOSS OF COOLANT ACCIDENTS</u>:	
IADS	Inadvertent ADS actuation (3 or more EMRVs open, discharging to torus)
LBI	Large below core break inside containment (recirculation line break, below core)
LBIO	RWCU overpressurization
LAIMS	Large above core break inside containment (Main steamline break inside drywell)
LAICS	Core spray line break inside containment
LAOMS	Large steamline break outside containment (unisolated break in Turbine Building)
LAOIC	Large steamline break outside containment (unisolated break in Reactor Building)

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Table 3.2.2-2. OCNGS - CDF Profile for Top 10 Contributors.

Initiator	Description	Frequency Per Year	Percent Contribution
LOSP	Loss-of-Offsite Power	1.21E-06	32.8
TT	Turbine Trip	4.85E-07	13.1
RT	Reactor Trip	2.83E-07	7.7
CMSIV	MSIV Closure	2.56E-07	6.9
LOFW	Total Loss of Feedwater	2.09E-07	5.7
LOCV	Loss of Condenser Vacuum	1.48E-07	4.0
LOTB	Loss of TBCCW	1.47E-07	4.0
LOIS	Loss of Intake Structure	1.20E-07	3.3
EPRL	Electric Pressure Regulator Failure (Sensing Low)	1.19E-07	3.2
LBI	Large Below Core Break Inside Containment	1.08E-07	2.9
	TOTALS	3.08E-06	83.6

Table 3.2.2-3. OCNGS - Top Event Importance by Independent Failure.

Top Event Description	Percent Contribution to CDF
EMRV Closure	48
4160V ac Essential Bus 1D	37
4160V ac Essential Bus 1C	37
125V dc Bus C	33
125V dc Bus B	31
Recovery from Loss of Offsite Power	26
Core Spray	21
Reactor Scram	6
4160V ac Bus 1A	5
4160V ac Bus 1B	4
Total Contribution to CDF	248

3.2.3 Plant Damage State Profile

In the PRA, transient initiating sequences can potentially end in one of the 114 plant damage states. Additionally, LOCA sequences can end in any of the 83 plant damage states; some the same as, and some different from, the transient plant damage states.

4. MAR-D DATABASE INFORMATION

4.1 Overview of the MAR-D Database Information

Data and information extracted from the OCNGS PRA were used to develop the SAPHIRE IRRAS-level database. The PRA does not provide event trees in graphical form. Instead, the PRA generates the event tree logic through event sequence diagrams, logic block diagrams, and split-fraction assignment rules. Using these data, event tree models and rules were created and loaded into MAR-D. A flow diagram showing the layout of the event trees developed for the IRRAS database is shown in Figure 1. It shows how the trees are linked. First, all initiating events are processed through the support state trees. Next, the initiating events go through one of the four sets of early accident trees. Finally, the initiating events go through either the late transient or late LOCA trees. It should be noted that although the IEMRV initiator is classified as a small LOCA, it is treated as a general transient and uses the transient logic throughout the event trees.

A comparison of the sequence quantification results reported in the PRA for the 100 dominant accident sequences, and the IRRAS quantified results generated using IRRAS for the same 100 sequences, is provided in Section 4.2.

The 100 dominant accident sequences were generated in IRRAS by quantifying all initiating events simultaneously, using a 3.91E-09 cutoff (the value of the last dominant sequence reported in the PRA). However, the total results reported in the PRA are based on the generation of all sequences using a cutoff of 1.0E-13. All sequences cannot be generated simultaneously when using IRRAS, because the number of sequences (approximately 34.5K) will exceed IRRAS's 10K storage limitation. Thus, the IRRAS sequences were generated for each initiating event separately. The results are reported in Section 4.2.

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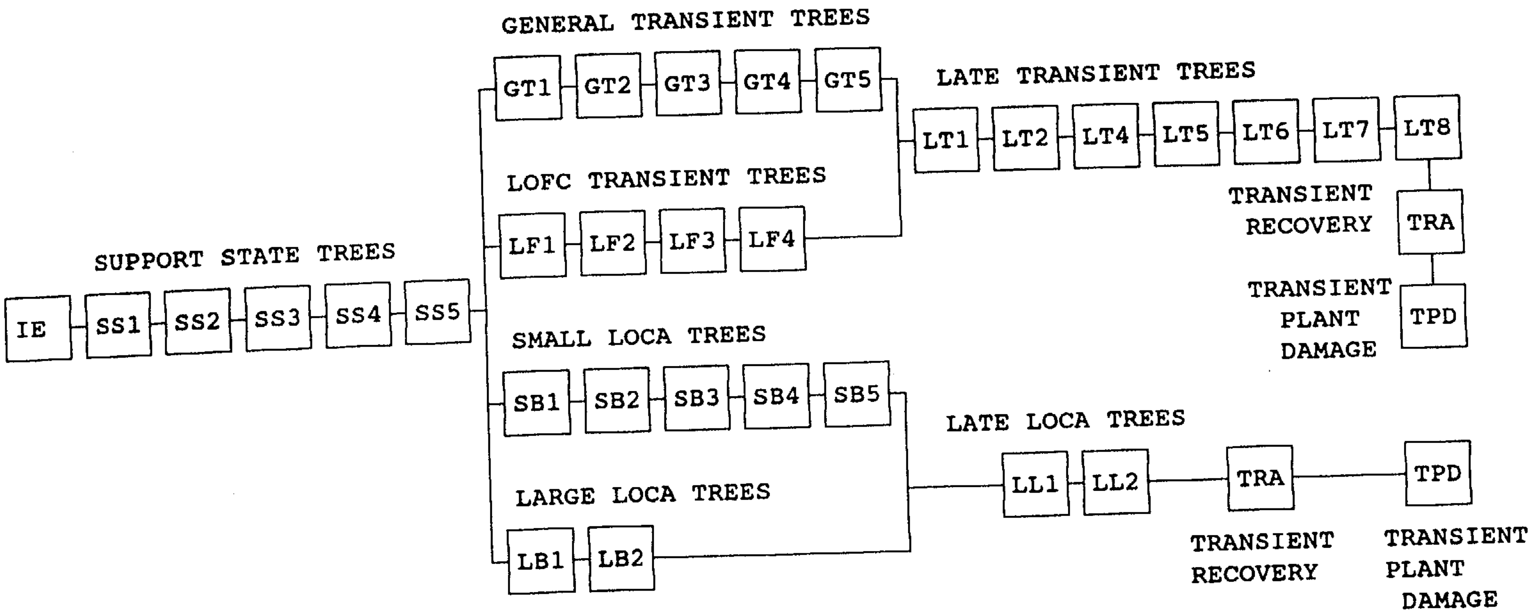

FIGURE 1. OCNGS EVENT-TREE FLOW DIAGRAM.

4.2 Accident Sequence Comparison

The 100 dominant accident sequence results reported in the OCNGS PRA were compared with the results generated using IRRAS. Again, the plant CDF reported in the PRA is 3.69E-06 per year. However, the total frequency for the 100 sequences listed in the PRA is 3.03E-06. The IRRAS calculated frequency for these same 100 sequences is also 3.030E-06. Although the total frequency suggests an exact match, differences do exist between some sequences. A comparison of the PRA and IRRAS results is provided in Table 4.2-1. Also, a summary report for the 100 dominant accident sequences can be displayed within the database or extracted from the database using either the IRRAS or SARA report features.

The total results reported in the PRA are based on the generation of all sequences using a truncation of 1.0E-13. The CDF calculated with IRRAS for the same truncation value is 3.58E-06 per year. To avoid the SAPHIRE 10K storage limit each sequence was quantified individually to the 1.0E-13 tuncation level, and then the sequence results were summed. The resultant CDF is in reasonable agreement with the PRA results. Comparisons of the PRA and IRRAS sequence results are provided in Table 4.2-2.

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Table 4.2-1. OCONGS - Dominant Accident 100 Sequences - IRRAS Compared to PRA.

PRA Initiator & Sequence No.	PRA Sequence Frequency	IRRAS Sequence Frequency	% Difference (IRRAS-PRA)
LOSP - 1	7.69E-07	7.692E-07	+3.0E-10
TT - 2	2.59E-07	2.592E-07	0.0
RT - 3	2.10E-07	2.104E-07	0.0
CMSIV - 4	1.23E-07	1.232E-07	0.0
LOSP - 5	1.16E-07	1.164E-07	0.0
LOTB - 6	1.04E-07	1.041E-07	0.0
LBI - 7	9.61E-08	9.609E-08	0.0
LBIO - 8	7.25E-08	7.252E-08	0.0
LOIS - 9	7.24E-08	7.241E-08	0.0
LOCV - 10	6.52E-08	6.524E-08	0.0
PLOFW - 11	5.18E-08	5.184E-08	0.0
EPRL - 12	5.17E-08	5.166E-08	0.0
LOFC - 13	4.88E-08	4.876E-08	0.0
LOFW - 14	4.40E-08	4.398E-08	0.0
LOSP - 15	3.59E-08	3.587E-08	-1.0E-11
SBI - 16	3.51E-08	3.509E-08	+3.0E-11
LOSP - 17	3.35E-08	3.350E-08	+1.0E-11
LOSP - 18	3.29E-08	3.287E-08	+1.0E-11
TT - 19	3.28E-08	3.277E-08	+2.0E-11
LOFW - 20	2.92E-08	2.930E-08	+1.2E-10
LOFW - 21	2.87E-08	2.873E-08	-1.0E-11
LOSP - 22	2.68E-08	2.684E-08	0.0
SBO - 23	2.48E-08	2.481E-08	0.0
TT - 24	2.23E-08	2.232E-08	0.0
LOFW - 25	2.19E-08	2.189E-08	-1.0E-11
IEMRV - 26	1.97E-08	1.969E-08	+1.0E-11
LOSP - 27	1.88E-08	1.885E-08	+1.0E-11
LOFW - 28	1.81E-08	1.810E-08	-1.0E-11
EPRH - 29	1.65E-08	1.653E-08	0.0
CMSIV - 30	1.55E-08	1.547E-08	0.0
CMSIV - 31	1.51E-08	1.511E-08	0.0
LOSP - 32	1.50E-08	1.498E-08	-1.0E-11
SAI - 33	1.48E-08	1.479E-08	0.0
CMSIV - 34	1.46E-08	1.459E-08	0.0
TT - 35	1.40E-08	1.399E-08	+1.0E-11

Table 4.2-1. (Continued)

PRA Initiator & Sequence No.	PRA Sequence Frequency	IRRAS Sequence Frequency	% Difference (IRRAS-PRA)
LOFW - 36	1.38E-08	1.382E-08	0.0
LOIA - 37(1)	1.26E-08	1.264E-08	0.0
SBI - 38(1)	1.26E-08	1.265E-08	+2.0E-11
SBI - 39	1.25E-08	1.246E-08	0.0
LOSP - 40	1.20E-08	1.203E-08	0.0
LOIS - 41	1.20E-08	1.199E-08	+1.0E-11
TT - 42	1.13E-08	1.133E-08	-1.0E-11
LOSP - 43	1.12E-08	1.119E-08	0.0
RT - 44	1.08E-08	1.076E-08	0.0
LOCV - 45	1.06E-08	1.058E-08	0.0
TT - 46	1.04E-08	1.037E-08	-1.0E-11
IEMRV - 47	9.64E-09	9.640E-09	0.0
SAI - 48	9.51E-09	9.515E-09	+3.0E-12
LOSP - 49	9.49E-09	9.489E-09	0.0
TT - 50	9.29E-09	9.299E-09	+8.0E-12
LOTB - 51	9.25E-09	9.254E-09	0.0
LOSP - 52	8.88E-09	8.887E-09	+3.0E-12
IEMRV - 53	8.40E-09	8.405E-09	+3.0E-12
EPRL - 54	8.35E-09	8.351E-09	-1.0E-12
LOCV - 55	8.27E-09	8.276E-09	+3.0E-12
SBI - 56	8.01E-09	8.016E-09	+3.0E-12
LOCV - 57	7.99E-09	7.988E-09	0.0
LOCW - 58	7.89E-09	7.893E-08	0.0
LOCV - 59	7.72E-09	7.716E-09	0.0
LOSP - 60	7.65E-09	7.654E-09	+3.0E-12
TT - 61	7.11E-09	7.101E-09	-9.9E-11
IEMRV - 62	6.82E-09	6.809E-09	-7.0E-12
CMSIV - 63	6.60E-09	6.604E-09	+2.0E-12
EPRL - 64	6.53E-09	6.530E-09	+3.0E-12
LOSP - 65	6.45E-09	6.457E-09	+2.0E-12
LOIS - 66	6.44E-09	6.436E-09	0.0
EPRL - 67	6.38E-09	6.376E-09	0.0
TT - 68	6.35E-09	6.350E-09	0.0
IEMRV - 69	6.25E-09	6.248E-09	-7.0E-12
EPRL - 70	6.16E-09	6.159E-09	0.0
TT - 71	6.10E-09	6.103E-09	0.0

Table 4.2-1. (Continued)

PRA Initiator & Sequence No.	PRA Sequence Frequency	IRRAS Sequence Frequency	% Difference (IRRAS-PRA)
IADS - 72	6.04E-09	6.050E-09	+5.0E-12
TT - 73	5.76E-09	5.757E-09	+2.0E-12
SAI - 74	5.75E-09	5.751E-09	+2.0E-12
IEMRV - 75	5.60E-09	5.605E-09	+5.0E-12
CMSIV - 76(1)	5.36E-09	5.350E-09	-5.0E-12
LOSP - 77(1)	5.34E-09	5.359E-09	+2.1E-11
LOSP - 78	5.26E-09	5.256E-09	0.0
TT - 79	5.11E-09	5.109E-09	-1.0E-12
TT - 80	5.05E-09	5.048E-09	-5.0E-12
RT - 81	4.95E-09	4.953E-09	0.0
CMSIV - 82	4.90E-09	4.895E-09	-6.0E-12
SBI - 83	4.84E-09	4.845E-09	+1.0E-12
LOTB - 84	4.77E-09	4.792E-09	+2.0E-11
LOTB - 85	4.70E-09	4.699E-09	0.0
LOSP - 86	4.62E-09	4.619E-09	+2.0E-12
RT - 87	4.59E-09	4.593E-09	+1.0E-12
LOFW - 88	4.45E-09	4.451E-09	+1.0E-12
PLOFW - 89	4.43E-09	4.428E-09	+1.0E-12
RT - 90	4.41E-09	4.411E-09	0.0
CMSIV - 91(1)	4.39E-09	4.391E-09	+4.0E-12
CMSIV - 92(1)	4.39E-09	4.389E-09	0.0
IEMRV - 93	4.28E-09	4.280E-09	-5.0E-12
TT - 94	4.27E-09	4.269E-09	0.0
LOFC - 95	4.20E-09	4.202E-09	0.0
RT - 96	4.10E-09	4.096E-09	-4.0E-12
TT - 97	4.05E-09	4.055E-09	0.0
LOFC - 98	4.04E-09	4.042E-09	0.0
LOSP - 99	4.01E-09	4.004E-09	-3.0E-12
TT - 100	3.91E-09	3.911E-09	+2.0E-12
TOTALS	3.03E-06	3.031E-06	

NOTES: 1. The order of these sequences was reversed in the IRRAS results.

Table 4.2.2. OCNGS - Initiating Event Results Comparison.
(Calculated using a 1.0E-013 truncation value)

Initiating Event	PRA Results	IRRAS Results	Difference (IRRAS-PRA)
RT	2.83E-07	2.83E-07	0.0
TT	4.85E-07	4.86E-07	+1.0E-09
EPRH	2.92E-08	2.92E-08	0.0
EPRL	1.19E-07	1.19E-07	0.0
CMSIV	2.56E-07	2.56E-07	0.0
LOFW	2.09E-07	2.07E-07	-2.0E-09
PLOFW	7.80E-08	7.76E-08	-4.0E-10
LOCW	2.14E-08	2.11E-08	-3.0E-10
LOCV	1.48E-07	1.47E-07	-1.0E-09
LOIA	3.12E-08	3.12E-08	0.0
LOIS	1.20E-07	1.18E-07	-2.0E-09
LOSP	1.21E-06	1.21E-06	0.0
LOTB	1.47E-07	1.47E-07	0.0
LOFC	8.38E-08	8.32E-08	-6.0E-10
SAI	5.28E-08	5.27E-08	-1.0E-10
IEMRV	9.00E-08	9.01E-08	+1.0E-10
SBI	9.47E-08	9.94E-08	+3.7E-09
SBO	2.64E-08	2.64E-08	0.0
SAOIC	8.50E-12	8.49E-12	-1.0E-14
SAORB	2.70E-11	2.67E-11	-3.0E-13
SAOTB	1.90E-09	4.19E-09	+2.3E-09
IADS	1.60E-08	1.68E-08	+8.0E-10
LBI	1.08E-07	1.09E-07	+1.0E-09
LBIO	7.70E-08	7.61E-08	+9.0E-10
LAIMS	1.37E-09	1.44E-09	+7.0E-11
LAICS	1.49E-09	1.54E-09	+5.0E-11
LAOMS	4.60E-10	4.62E-10	+2.0E-12
LAOIC	4.00E-11	4.02E-11	+2.0E-13

5. DATABASE QUALITY CONTROL

5.1 Internal Quality Assurance Checks

Internal quality assurance (QA) checks of the individual MAR-D database files were made to ensure that all data loaded into MAR-D are complete and accurate. The IRRAS generated dominant accident sequences and quantified results were verified against the results reported in the OCNGS PRA.

5.2 Independent Review

An internal independent review of the OCNGS SAPHIRE IRRAS-level database was conducted by Mr. Dan Henry (Reference 9). The review included a thorough check of the basic event data and the sequence results. Sequences were regenerated and quantified to verify consistency and reproducibility. Random checks of the textual information and database reports were done. All problems identified were resolved.

6. PRA-RELATED DATA PROBLEMS AND REQUIRED MODIFICATIONS

This section discusses those problems and discrepancies identified during the development of the OCNGS SAPHIRE IRRAS-level database. Also, the contents of the database, and any modifications required to load the PRA data into MAR-D, are briefly discussed.

6.1 Event Tree Data

A significant effort was required to create event tree models for use in IRRAS. The new PLG methodology used to develop the PRA does not provide event tree or fault tree models in graphical form. Instead, event tree logic is defined as event sequence diagrams, logic block diagrams, and split-fraction assignment rules. The event trees graphics created for use in IRRAS were developed from these rules and diagrams. To avoid confusion, and eliminate duplicate top event names (not allowed in IRRAS) as used in the PRA, the following event names were modified when loaded into MAR-D:

Table 4.2.2. OCNGS - Initiating Event Results Comparison.
(Calculated using a 1.0E-013 truncation value)

Initiating Event	PRA Results	IRRAS Results	Difference (IRRAS-PRA)
RT	2.83E-07	2.83E-07	0.0
TT	4.85E-07	4.86E-07	+1.0E-09
EPRH	2.92E-08	2.92E-08	0.0
EPRL	1.19E-07	1.19E-07	0.0
CMSIV	2.56E-07	2.56E-07	0.0
LOFW	2.09E-07	2.07E-07	-2.0E-09
PLOFW	7.80E-08	7.76E-08	-4.0E-10
LOCW	2.14E-08	2.11E-08	-3.0E-10
LOCV	1.48E-07	1.47E-07	-1.0E-09
LOIA	3.12E-08	3.12E-08	0.0
LOIS	1.20E-07	1.18E-07	-2.0E-09
LOSP	1.21E-06	1.21E-06	0.0
LOTB	1.47E-07	1.47E-07	0.0
LOFC	8.38E-08	8.32E-08	-6.0E-10
SAI	5.28E-08	5.27E-08	-1.0E-10
IEMRV	9.00E-08	9.01E-08	+1.0E-10
SBI	9.47E-08	9.94E-08	+3.7E-09
SBO	2.64E-08	2.64E-08	0.0
SAOIC	8.50E-12	8.49E-12	-1.0E-14
SAORB	2.70E-11	2.67E-11	-3.0E-13
SAOTB	1.90E-09	4.19E-09	+2.3E-09
IADS	1.60E-08	1.68E-08	+8.0E-10
LBI	1.08E-07	1.09E-07	+1.0E-09
LBIO	7.70E-08	7.61E-08	+9.0E-10
LAIMS	1.37E-09	1.44E-09	+7.0E-11
LAICS	1.49E-09	1.54E-09	+5.0E-11
LAOMS	4.60E-10	4.62E-10	+2.0E-12
LAOIC	4.00E-11	4.02E-11	+2.0E-13

6.4.1 Split Fraction Correlation

The OCNGS PRA split-fractions representing the systems and plant functions are independent. Thus, split fractions are not correlated in the SAPHIRE database.

6.4.2 Uncertainty Data

The split-fraction uncertainty data reported in Table 9.1-2 of the PRA were manually loaded into MAR-D. Using these data, a Monte Carlo uncertainty analysis was performed on the 100 dominant accidents. The results reasonably reflect the uncertainty results reported in the PRA for the split-fractions. Because no results were found in Table 9.2-1 of the PRA for the following split-fractions, the IRRAS results are presumed to be valid: EC3, ED5, MS2, RA1, RC1, RC2, RC3, RC4, RC5, RC7, RC8, RC9, RCA, RCB, and RD1.

6.5 Sequence Recovery

Sequence recovery rules are not included in the OCNGS IRRAS-level database, as none were included in the PRA. The recovery of offsite electric power is addressed in the late-transient event trees, and failed containment environmental-control systems are addressed in the recovery portions of the event tree logic.

6.6 Cut Set Pruning

Mutually exclusive event rules are not included in the OOCNGS IRRAS-level database. The event tree logic rules and system fault logic, as they were written, preclude the possibility of mutually exclusive events occurring simultaneously.

6.7 Sequence Change Sets

No "Change Sets" are included in the OCNGS IRRAS-level database.

6.8 Piping and Instrumentation Diagrams

Piping and instrumentation diagrams (P&IDs) are not included in the OOCNGS IRRAS-level database.

7. DATABASE APPLICATION

7.1 Overview

Data and information were extracted from the PRA (Reference 1) to develop the OCNGS SAPHIRE IRRAS-level database. It is the intent of this letter report to provide a brief overview of the PRA and the SAPHIRE IRRAS-level database. The letter report also includes any problems or concerns identified with the data and information, and any special procedures that must be carried out to use the SAPHIRE database. It is not the intent to provide detailed instructions in the use of the SAPHIRE codes (see References 3 through 8), nor provide procedures and instructions for developing the SAPHIRE database.

The OCNGS SAPHIRE database is an IRRAS-level load; the dominant accident sequence results were generated using the event-tree models loaded into MAR-D. As stated in Section 6.2, the number of fault tree gates exceeds the 10K storage limit in SAPHIRE. Thus, no fault tree models are included. A comparison of the IRRAS and PRA dominant accident sequence quantified results are presented in Table 4.2-1 in Section 4. To examine the accident sequences for any given initiating event or group of initiating events in greater detail, the appropriate accident sequences must be generated, quantified, and gathered using the desired cutoff value.

Because some event tree models are generic in nature (e.g., transient trees), special initiating event trees were created for use in IRRAS. These initiator event trees involve a single branch that initially transfers to the support state event tree models. Upon transferring from the support state event trees, a logic rule selects the proper event tree path for each initiating event. If the logic for any event tree is revised, the affected initiating event tree models will need to be revisited to ensure they remain applicable.

Copies of all event tree models (including the initiator models), can be viewed within the database, or extracted in hard-copy form, or as electronic files (*.ETG or *.ETL).

Probabilities for many event tree tops are dependent upon the initiating event used. Using the rule-based free-format event tree rule feature in IRRAS, rules were created that correctly assign the split-fractions to the event tree tops. These rules can also be viewed within the database or extracted as a file (OYCREEK.ETR). Given the logic for an event tree with rules is modified, the rules need to be reviewed for validity.

8. REFERENCES

1. GPU Nuclear Corporation, et al., "Oyster Creek Probabilistic Risk Assessment (Level 1)," November 1991.

2. NRC Form 189, "Plant Database Development for SAPHIRE," FIN W6241, August 1994; Task 2.4, "Add the Oyster Creek Plant into MAR-D 5.0."

3. K. D. Russell et al., "Systems Analysis Programs for Hands-on Integrated Reliability Evaluations (SAPHIRE), Version 5.0, Volume 2--Integrated Reliability and Risk Analysis System (IRRAS) Reference Manual," NUREG/CR-6116 (EGG-2716), December 1993.

4. R. L. VanHorn et al., "Systems Analysis Programs for Hands-on Integrated Reliability Evaluations (SAPHIRE), Version 5.0, Volume 3--Integrated Reliability and Risk Analysis System (IRRAS) Tutorial Manual," NUREG/CR-6116 (EGG-2716), December 1993.

5. K. D. Russell et al., "Systems Analysis Programs for Hands-on Integrated Reliability Evaluations (SAPHIRE), Version 5.0, Volume 4--Systems Analysis and Risk Assessment (SARA) System Reference Manual," NUREG/CR-6116 (EGG-2716), December 1993.

6. M. B. Sattison et al., "Systems Analysis Programs for Hands-on Integrated Reliability Evaluations (SAPHIRE), Version 5.0, Volume 5--Systems Analysis and Risk Assessment (SARA) System Tutorial Manual," NUREG/CR-6116 (EGG-2716), December 1993.

7. K. D. Russell and N. L. Skinner, "Systems Analysis Programs for Hands-on Integrated Reliability Evaluations (SAPHIRE), Version 5.0, Volume 8--Models and Results Database (MAR-D) Reference Manual," NUREG/CR-6116 (EGG-2716), December 1993.

8. M. K. McKay et al., "Systems Analysis Programs for Hands-on Integrated Reliability Evaluations (SAPHIRE), Version 5.0, Volume 7--Fault Tree, Event Tree, and Piping and Instrumentation Diagram (FEP)Editors," NUREG/CR-6116 (EGG-2716), December 1993.

9. Dan Henry letter to R. D. Fowler, Subject: Review of Oyster Creek SAPHIRE IRRAS-level database, I-9411202-001, March 1, 1995.