PROBABILISTIC RISK ASSESSMENT

NORTH ANNA POWER STATION

SERVICE WATER PRESERVATION PROJECT

PART ONE

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Final Report
Revision 2

Prepared for

VIRG IA ELECTRIC AND POWER COMPANY

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Revision one is produced to reflect two additional cables in the Appendix A Cable List. Additional cables and their functions are shown in Appendix A and are identified by correction mark on the right hand column of the page.

Revision 2 is produced to reflect the correction of two typing errors on pages 35 and 39. The corrected items are underlined.

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SECTION 1
INTRODUCTION

The probabilistic risk assessment (PRA) of the first part of the Service Water Preservation Project at Virginia Power Company's North Anna Power Station (NAPS) is documented in this report. The background and objectives of the study are described in this section. The methodology for performing the risk analysis is provided in Section 2. The results of the risk analysis calculations are presented in Section 3. Section 4 contains a summary of the conclusions and recommendations of the analysis.

1.1 BACKGROUND

The Service Water System piping at the North Anna Power Station is experiencing wall degradation because of general corrosion and relatively rapid wall loss in localized areas because of microbiologically induced corrosion. Several sections of small diameter carbon steel pipes have been replaced with stainless steel material. A pipe rehabilitation project has been undertaken to clean, weld repair and coat large diameter buried service water piping.

The restoration work on the service water system will be conducted in five different parts. The work in Part 1 will be performed during the 1993 Unit 1 Steam Generator repair/refueling outage and will involve repair and partial replacement of the service water lines to Unit 1. The work in Part 2 will be conducted with both units operating and involves installation of manways on 36" main service water headers. The work in Part 3 involves repair and partial replacement of service water lines to Unit 2 and is planned for the Unit 2 outage in 1993. Part 4 will consist of repair and partial replacement of the auxiliary service water lines while both units are operating. Part 5 will consist of repair of the service water piping connected to the component cooling heat exchangers and will be conducted during a planned outage in 1994 or 1995.

During the restoration project, it will be necessary to excavate and backfill in the Unit 1 and Unit 2 alleyways and in the yard north of the Turbine Building. New manway accesses will be

installed on 36" main headers west of Unit 2 (outside the auxiliary boiler room), on 24" auxiliary service water lines in the north yard and below the basement of the Turbine Building.

The service water system is shared between the two units. It provides the ultimate heat sink capability for normal plant operation and for mitigating the consequences of a design basis event. Performing these restoration projects will require isolation of one train of service water for brief periods to install and subsequently remove blocking devices to the affected sections. Unit operation at power with a single train of service water is allowed for periods of up to seven days by plant technical specifications (Reference 1). However, reducing the redundancy of the service water system through repeated use of the seven day action statement may contribute to increasing the risk of an accident resulting in core damage.

Excavation of the buried service water lines will expose the lines and some electrical conduit ducts to possible hazards which may interrupt power to critical equipment. The normal design basis protection against natural phenomena afforded by the earth and concrete will be temporarily removed during the excavation. This will require a temporary exemption, to be approved by the Nuclear Regulatory Commission, from 10 CFR Part 50, Appendix A, "General Design Criteria (GDC) for Nuclear Power Plants". Specifically, criteria 2 (GDC-2) requires design protection against the effects of natural phenomena (e.g., earthquake, tornadoes) for components, systems, and structures important to safety.

To evaluate these possible risks, a PRA of applicable parts of the service water preservation project will be performed. This report documents the PRA of Part 1 of the project, affecting the Unit 1 service water lines. The PRA analyses of other parts of the project will be documented separately.

1.2 ANALYSIS OBJECTIVES

The principal objective of this PRA analysis of Part 1 of the service water preservation project is to determine the effects, if any, of the project activities on the core damage frequency (CDF)

of the operating units. An additional objective is to identify specific measures to further reduce the risks associated with the project. The third objective of the analysis is to provide a documented basis for a temporary exemption GDC-2 of 10 CFR Part 50, Appendix A, "Design Basis for Protection Against Natural Phenomena."

SECTION 2
TECHNICAL APPROACH

This report covers the risk assessment of Part 1 of the service water preservation project; i.e., repair and partial replacement of the Service Water (SW) lines to Unit 1 components. The risk analysis for the remaining parts of the project will be provided in separate reports. The approach for performing this risk analysis is described in the following sections.

2.1 GENERAL APPROACH

The overall approach for performing the probabilistic risk assessment (PRA) of the Unit 1 SW preservation project is illustrated in Figure 2-1.

The first step is to itemize the equipment that will be isolated or unavailable during the construction period as well as potential hazards which could damage other components or structures during construction operations. A review of the preliminary design change package and other project plans was made to determine the details of the scope of work to be performed. Systems and components to be isolated during the project were itemized.

A plant walkdown of the affected areas was performed at the beginning of the PRA task to help in the hazard identification process.

Plant drawings were reviewed and a survey of the areas of construction was carried out to identify structures or components which will be exposed to damage by construction activities or external hazards like earthquakes or tornadoes. Using data in the Individual Plant Examination (IPE) system notebooks, plant P&IDs and information provided by Virginia Power, components in safety and support systems which would be affected by these hazards were identified. The result of this step was a listing of possible hazards, the systems or structures which could be damaged, the components which would be unavailable, and the effect of the component unavailability on plant operations.

Figure 2-1

Approach for Probabilistic Risk Assessment of Service Water Restoration Project

1. **Itemize Potential Hazards and Component Unavailabilities**

   - Planned equipment unavailability
   - Equipment unavailable due to accidental damage during construction

2. **Revise IPE Model to Quantify CDF During Construction Period.**

   - Potential Initiating Events caused by equipment unavailability
   - Unavailability of Safety or Support Systems
   - Modify maintenance unavailabilities

3. **Evaluate Countermeasures**

   - Identify critical items
   - Determine countermeasures for specific items
   - Calculate reduction on CDF for candidate countermeasures

The second step in the approach was to revise the North Anna IPE model to quantify the Units 1 and 2 CDF during the construction period. In revising the model, the planned unavailability of portions of the SW system was accounted for by failing that portion of the service water header. Potential initiating events and system unavailabilities which could result from the hazards identified in step one were also included. An additional modification to the model was to remove the following maintenance unavailability terms for planned maintenance actions which would not be conducted during the one header operation of the SW system:

- o Three out of four SW pumps and both Auxiliary SW pumps
- o 4160 VAC bus 1H, 1J, 2H, and/or 2J
- o Diesel Generators which would power operable SW Pumps

This modification was based on the assumption that during the periods that one SW header is unavailable, no maintenance will be performed on components affecting the reliability of the other SW header.

The revised IPE model was used to determine the change in Units 1 and 2 CDF during the construction period. The result of this step is the quantification of the increase in the probability of a core damage event during part one of the SW preservation task as compared to the baseline value determined from the IPE.

The third step was to evaluate the effectiveness of any countermeasures to reduce CDF during the construction period. Candidate countermeasures include methods to accurately locate underground ducts prior to excavation, barriers to prevent damage, or changes to maintenance and test schedules for systems important to accident mitigation.

Based upon review of the planned activities for the Unit 1 SW system preservation work and a survey of the work area, it was determined that the planned approach involved two sets of activities which could potentially increase the risk of the operating units. These activities are summarized as follows:

1. Excavation of the Unit 1 SW lines will be performed prior to the outage while the unit is operating. Backfill of the area may be performed after restart, depending on the duration of the preservation task and other outage activities. During the excavation and backfill, there is a possibility of damage to the SW lines or the overlaying cable ducts resulting from construction mishaps. Additionally, the SW lines and cable ducts may be more vulnerable to damage from external events (e.g., earthquake).

2. During the restoration work, each SW header must be isolated and partially drained to install and remove blocking devices on the Unit 1 SW lines. This will result in a loss of redundancy in the SW system for the operating Unit 2 for six periods of up to seven days.

The approach for assessing the possible risk impact and effective countermeasures for each of these items is discussed in the following sections.

2.2 DESCRIPTION OF EXCAVATION AND BACKFILL ACTIVITIES

The excavation site for the Unit 1 SW lines is located between the Quench Spray Pump House and the Main Steam Valve House to the south, and the Service Building to the north (see Figure 2.2). This area is called Unit 1 alleyway.

The SW lines are composed of four 24" pipes, two supply and two return headers, to and from the Unit 1 Recirculation Spray heat exchangers. In addition, four 4" SW pipes for the Unit 1 control room air conditioning condensers, each connected to a 24" SW line at an elevation of approximately 258'-0", are present (see Figure 2.3).

Cable duct lines P and N are buried directly above the SW lines. Figure 2.3 shows a cross-sectional view of the planned excavation site.

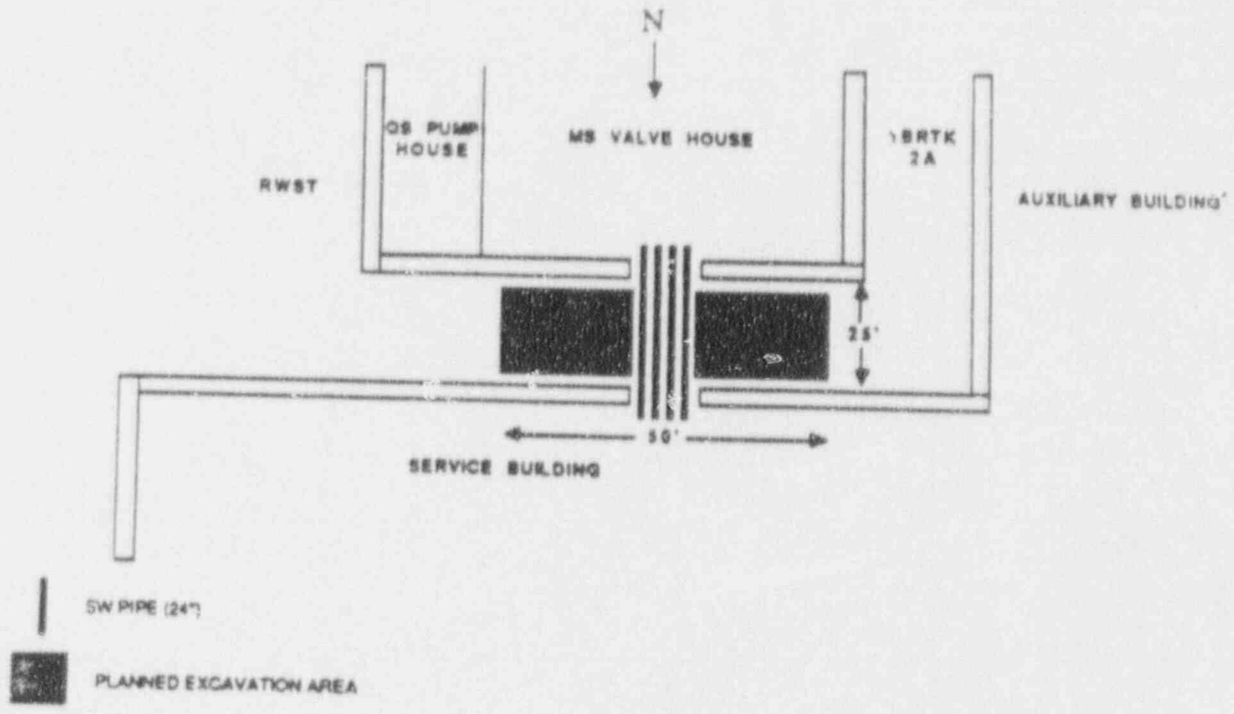


Figure 2.2 - Unit 1 Alleyway Excavation Site

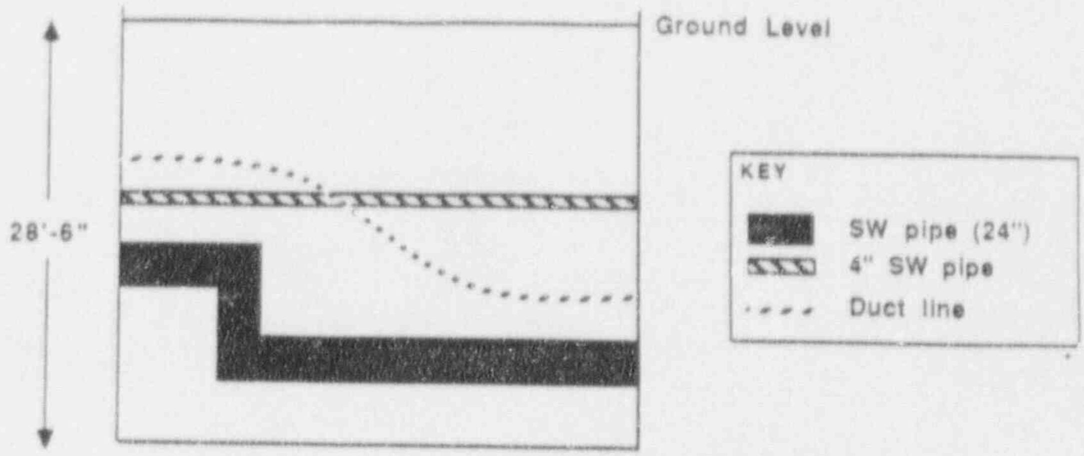


Figure 2.3 Excavation Area (Cross-section View)

The project consists of replacing the 24" SW pipes in the Unit 1 alleyway and will be performed in three steps. In Step 1, the excavation will start and will proceed to the level of the SW pipes. Step 1 is planned to take about 30 days and will be performed prior to the Unit 1 shutdown. Following Unit 1 shutdown, Step 2 will begin. This step is anticipated to last about 120 days or the entire outage period. During this step, the SW pipes will be replaced and repairs to some parts of SW pipes will be performed. Step 3 is the backfill of the excavation site which may be performed after Unit 1 restart.

The following specific steps will be performed during the excavation and backfilling operations.

Excavation Steps

1. Breaking of the existing pavement, between the Service Building and MS Valve House, within the alleyway will be performed using pneumatic equipment (i.e., air compressor and jackhammers). Removal of debris will utilize a backhoe-loader (wheel type) to dump the material into dump trucks.

2. The subgrade directly below the pavement will be machine excavated with a backhoe-loader. Machine excavation will be performed up to a point approximately 2 feet above the N and P electrical duct lines. All excavated material will be transported away from the excavation area with dump trucks as in item 1.

3. All remaining excavation will be performed with hand powered tools and conventional pick and shovel tools. Excavated material will be hauled out of the pit using a conveyor that will transport the material directly into dump trucks for removal. Excavation will proceed until four SW pipes are exposed and will continue approximately 2 feet below the bottom of the pipes for a total depth of 28'-6" below the alleyway pavement.

   Shoring of the excavation will be required, although the method of shoring has not yet been determined. In any case, pile driving equipment will not be used. It is anticipated that soldier piles, installed in short segments, with timber lagging spanning horizontally between the piles will be utilized. Installation of the piles and lagging will be with a truck mounted crane. It is

anticipated that the excavation will remain open during the scheduled Unit 1 outage.

Backfilling Steps

1. Backfilling operations will begin upon completion of the SW pipe rehabilitation and may occur subsequent to returning Unit 1 on-line.

   Backfilling will be accomplished by unloading backfill material from dump trucks into a concrete bucket (a bucket normally used for placement of concrete) supported by a truck mounted crane. The backfill material will be placed as needed with the crane and compacted with engine powered, hand operated compactors. Alternatively, the material may be conveyed into the excavated area in a manner similar to its removal.

2. Vertical compaction of the soil will be performed as close as possible to beneath the existing duct lines. Backfilling will continue, closing one side of each duct line then horizontal compaction by hand will be performed within the remaining areas below the duct lines. If proper soil compaction can not be achieved beneath the duct lines, then lean concrete fill may be used within these areas.

3. Upon completion of the backfilling operations, the pavement within the excavated area will be restored with new concrete paving.

During these excavation and backfill steps, there may be a potential for damage to the cable ducts or SW lines due to construction mishaps. The possible risk effects of damage to these systems were reviewed as described in the following sections.

2.2.1 POSSIBLE CONSEQUENCES OF DAMAGE TO DUCTS

A review of electrical loads supplied by cables in the exposed duct lines was performed. A list of all the cables in the N and P duct lines was prepared to determine the potential consequence of the damage to the duct lines (Reference 2). The review was conducted in several steps, including:

1. Review of the cables to screen out, based on the system designators, non-risk contributing cables.

2. Identification of the origin (FROM) and the destination (TO) of all the remaining cables.

3. Identification of the Loads (Affected Components). Using the data banks, and pertinent engineering drawings the affected components were identified.

The results of the cable review are presented in Appendix A. No component (or group of components) failures which would result in an initiating event (plant trip, either manual or automatic) were identified. Accident mitigating components which could be disabled as a result of the cable damage include:

- o two (2) Outside Recirculation Spray (ORS) pumps,
- o two (2) motor driven Auxiliary Feedwater (AFW) pumps,
- o two (2) Low Head Safety Injection (LHSI) pumps.

Plant technical specifications require the plant to commence shutdown within 72 hours if any of these pumps are inoperable. Therefore, the worst case consequence of damage to the P or N cable ducts would be a reduced capability for Unit 1 safety systems during the brief period prior to unit shutdown.

The IPE model was modified to include damage to the cable duct as a common mode failure resulting in unavailability of the affected pumps. This revised model was used to determine the effect of the probability of damage to the cable ducts on Unit 1 CDF.

2.2.2 POSSIBLE CONSEQUENCES OF DAMAGE TO UNIT 1 SERVICE WATER LINES

The SW lines to be excavated are the supply and return headers for the recirculation spray heat exchangers in Unit 1. There are no valves to isolate these lines from the main SW headers. Technical specification require both units to be shutdown if one SW header becomes inoperable and cannot be restored within seventy-two hours. This allowable outage time is extended to 168 hours for service water upgrades.

Damage to one SW line which resulted in a small leak would interrupt the excavation activities and ultimately require shutdown of the SW header to accomplish repairs. A large break would require immediate shutdown of the affected SW header and probably result in shutdown of both units within several days. Neither a small or large break in a single SW line would, by itself, initiate a core damage sequence.

The IPE model was revised to represent Unit 1 operation with one train of SW unavailable. This model was used to determine effect of the probability of SW line damage on units 1 and 2 CDF.

Damage to two SW lines connected to train A and B SW headers which resulted in a large break or rupture could cause a total loss of SW. This initiating event has been analyzed in the NAPS Individual Plant Examination (IPE). The loss of SW accident sequence, designated T6, can

result in core damage due to one of the following reasons. Loss of SW will result in loss of cooling to emergency switchgear which induces a station blackout. Loss of SW will also result in a loss of RCP seal cooling, a loss of component cooling to the RCPs, and a loss of instrument air compressors. Each one of these initiators can result in a plant trip.

The IPE model was revised to include damage to two SW lines as a contributor to the T6 event frequency. This model was used to determine the effect of the probability of this event on CDF.

2.3 CONSTRUCTION HAZARD ASSESSMENT

The probability of a construction mishap resulting in damage to the cable ducts or SW lines is dependent on a wide range of situational factors and is very difficult, if not impossible to quantify. For this reason, a qualitative hazard assessment was performed, to identify the possible hazards to the electrical ducts and service water lines during excavation and backfill. The assessment was conducted by reviewing the existing project work plans, surveying the site of the excavation and surrounding areas and interviewing plant personnel with experience in previous projects of a similar nature. The hazard assessment was performed by a civil engineer with extensive experience in excavation projects accompanied by a risk analyst.

Each step of the excavation was carefully analyzed to identify possible hazards, their causes, and possible preventive measures. The assessment results were reviewed with project engineers and construction personnel to ensure the completeness of the hazards evaluation and the feasibility of the preventive measures. The results of the hazard assessment are presented in Section 4.

2.4 ASSESSMENT OF HAZARDS FROM EXTERNAL EVENTS

During the period of excavation and backfill, the SW lines and cable ducts will not have the level of protection from external events normally provided by the soil and concrete pavement.

External events (e.g., earthquakes, floods, tornadoes, aircraft impacts, etc.) were analyzed to evaluate the degree of hazard posed by externally initiated events to the safety of the exposed cables ducts and SW lines. The screening approach described in NUREG/CR-4340 (Reference 3) was used to determine the events of possible concern. For external events which could not be qualitatively screened, quantitative analyses to determine the frequency of occurrence were performed.

The screening of external events to select the significant risk contributors consists of several steps. First, all possible external events specific to the site and plant are identified (see Table 2.1). The screening process is performed at two levels. At the first level, all external events which do not directly impact the site of question are eliminated from further consideration. At the second level, events are screened out based on the following screening criteria:

- o The event is impossible or has an extremely remote probability
- o Barriers or protective measures eliminate the effect of the event
- o The effect of the event is not changed by the excavation

Using the established criteria, each external event is independently reviewed to find out if more detailed analysis of the event is required. All those external events that are discarded as being insignificant are documented and the reasons for not performing a more detailed analysis are reported. The reason for exclusion of these events are also provided in Table 2.1.

It should be noted that external flooding was initially considered a credible event. The SW lines in the excavation and the SW manways in the auxiliary building will be open while work on the piping is performed. This introduces a possible flooding path through the open pipe to the auxiliary building. There are two possible sources of flood of significant magnitude. First, flooding due to the failure of the SW reservoir earth dam. Second, flooding due to the rupture of the RWST. Flood from high lake water is impossible because of the plant elevation which is above the maximum expected lake surface elevation, including coincident wind and wave activity (NAPS UFSAR Section 2.4). Heavy rainfall cannot cause flooding of high magnitude

over a short period of time because the plant site is graded such that surface runoff will flow away from the excavation area.

The possibility of SW reservoir earth dam failure is remote. Even if a catastrophic failure of the dam occurs, the site is graded in such a way that any water spillage will flow away from any safety-related facilities through a ditch into the lake. Similarly, flooding caused by the failure of the RWST is not possible. The base of the tank is below the elevation of the alleyway and the slope will carry water away from the excavation. Therefore, there is no possible external flood source.

It was also determined that the risk of sabotage or deliberate damage to the structures will not be affected. The excavation is completed within the protected area and the SW pipes and cables will have the same level of security as is normally provided elsewhere in the plant.

Events surviving the elimination process (e.g., Earthquake, and Tornadoes/High Winds) were analyzed in more detail. In general, the risk from these external events are assessed using a two-step method:

1. Evaluation of the occurrence frequency of a particular external event as a function of severity, such as peak ground acceleration for seismic analysis, wind speed for high winds, etc.

2. Evaluation of the impact of the event on the duct lines and SW pipes as a function of severity of the event.

The degree to which it is necessary to perform a detailed analysis depends on the frequency of the event occurrence. The following sections discuss the quantification of the frequency from each of the external event of interest.

TABLE 2.1

Qualitative Screening of External Events

Event	Cause for Exclusion
Aircraft Impact	Remote, no airports in plant vicinity
Avalanche	Impossible
Earthquake	Cannot screen
Fire in Plant	No effect on excavated area
Fire Outside Plant but on Site	No effect on excavated area
Fire Offsite	No effect
Flammable Fluid Release	Significant quantities of flammable fluid prohibited
Flooding, External	No flood source
Flooding, Internal	No effect on excavated area
Tornadoes	Cannot screen
High Winds	Consider under tornado
Industrial or Military Accident Offsite	No industrial or military facilities in area
Landslide	Impossible
Lightning	No effect
Meteorite Impact	Extremely remote
Pipeline Accident	No pipelines in area
Ship Impact	No effect on excavated area
Sabotage	Excavation is inside protected area
Toxic Gas Release	No effect
Transportation Accident	No effect
Turbine Missile	No effect
Volcanic Activity	Extremely remote

2.4.1 FREQUENCY OF SEISMIC EVENTS

Excavation activities will remove the surrounding and supporting soil for the safety-related cable ducts, N and P, during the Unit 1 alleyway excavation. As a result, these structures will not remain qualified for seismic loads during the excavation period. Therefore, an evaluation of the change in the plant operational risk, as measured by the change in the Core Damage Frequency (CDF), will be necessary, if appropriate seismically qualified supports are not provided.

Conservative analyses were performed to evaluate the feasibility of dismissing the increase in risk from seismic events, at a low level of detail. The analysis included an evaluation of the probability of an earthquake event during the period that Unit 1 is operating with the excavation or backfill in progress. To determine earthquake frequency, hazard curves were taken from two sources (Reference 4 and 5). The first set of hazard curves was from the NRC-sponsored Eastern US Seismic Hazard Characterization Program, performed by Lawrence Livermore National Laboratories (LLNL). A second set of hazard curves was obtained from the industry-sponsored Electric Power Research Institute Seismic Hazard Methodology Development program. These curves are shown in figures 2.4 and 2.5 respectively.

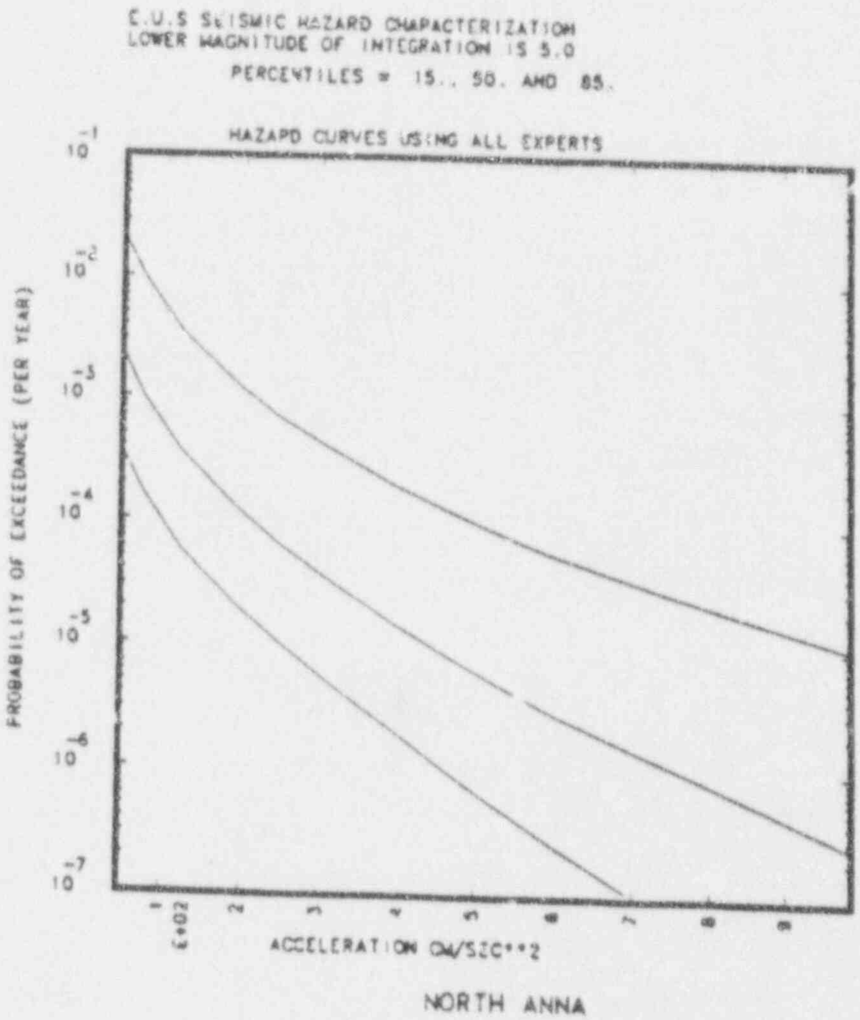


Figure 2.4

LLNL Seismic Hazard Curves Mean, Median, 15th and 85th Percentiles

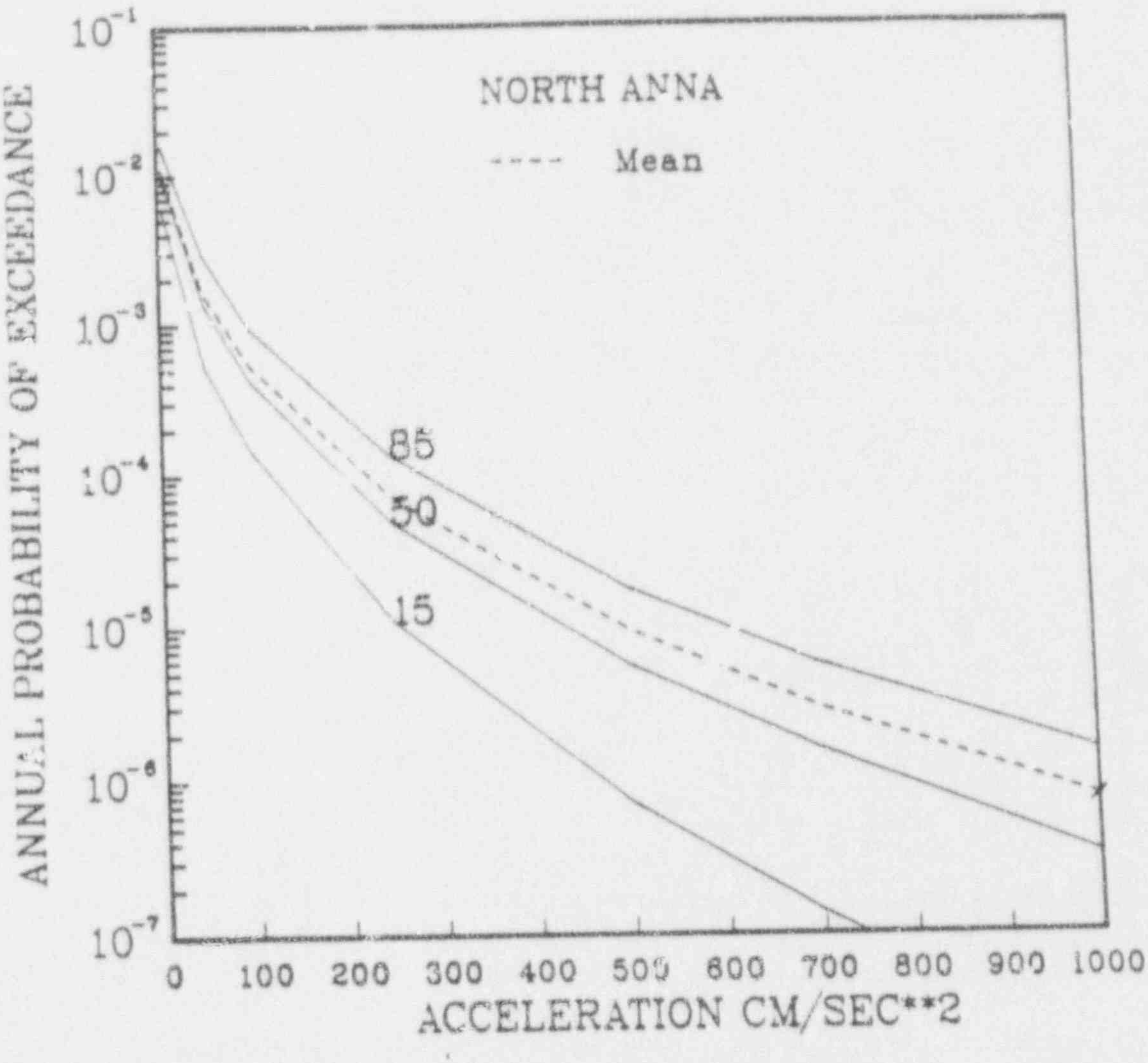


Figure 2.5

EPRI Seismic Hazard Curves Mean, Median, 15th and 85th Percentiles

The NAPS seismic design basis for components in soil is an event with a peak ground acceleration of 0.18g (175 cm/s^2). For this acceleration value, the 85 percentile earthquake frequencies from Figure 2.4 and 2.5 are approximately 2E-3 and 4E-4 per year, respectively. These translate to a probability of 3.4E-4 and 6.5E-5 during the two 30-day periods. These values are considerably above the 1E-6 value typically used as a threshold for non-credible events. Therefore, the earthquake probability cannot be used as a screening criteria and the consequences of occurrence of earthquake have to be considered.

Damage to the SW lines and cable ducts will not necessarily result in a core damage event. However, to determine a change in the seismic-induced Core Damage Frequency (CDF) from the SW restoration project, one would need to know the seismic CDF of the plant under normal operating conditions. This determination of seismic CDF is beyond the scope of this document. It is therefore conservatively assumed that the probability of core damage from exposed unsupported SW lines and cable ducts is at worst equivalent to the mean probability of accident design basis seismic event.

Therefore, it is recommended that measures be taken to ensure that the exposed SW lines and cable ducts will be supported by supports that will meet all appropriate acceptance criteria stated in the UFSAR for a plant design basis seismic event.

2.4.2 FREQUENCY OF TORNADOES/HIGH WIND HAZARD

Two data sources were used to quantify the frequency of tornadoes and high wind events. ANSI/ANS 2.3-1983, "Standard for Estimating Tornado and Extreme Wind Characteristics at Nuclear Power Sites", (Reference 6) provides data on the probability of occurrence of various wind velocities. For the Virginia area, these data are summarized on Table 2.2

The probability of high winds during the period of Unit 1 operation with the cable ducts exposed is obtained by multiplying the annual probability by the fraction of the year spent in that configuration.

Table 2.2

Wind Speed (MPH)	Probability (per year)	Probability (per 60 days)
150	1E-5	1.6 E-6
200	1E-6	1.6 E-7
250	1E-7	1.7 E-8

The NAPS UFSAR (Reference 7), also provides data on the frequency of tornado events. The UFSAR estimates the annual probability of a tornado striking any point in the plant as 3.3 E-5 per year, based on historical data for the area. For the 60 day exposure per [illegible] the probability is 5.4E-6.

Both data sources indicate that the probability of a tornado or high wind event occurring during the period that Unit 1 is operating is slightly above 1E-6. However, missile damage to the cable ducts during such an event is not certain. The ducts are several feet below grade and would only be damaged by a large missile (e.g., vehicle, large beam) dropping into the excavation.

Determining the probability of missile strikes on the structures would require a simulation analysis. Previous studies of similar situations (Reference 13) have calculated the probability of missile strike on a structure in the range of 6 E-2 to 1.8 E-2. However, a conservative assumption in this case is that the probability of missile strike, given a tornado event, is .25. This accounts for the fact that the excavation is surrounded by buildings on three sides. The probability of large missile strikes could be further reduced by adopting a policy of moving all vehicles and other objects at least 200 feet from the excavation upon notification of a tornado watch in the area.

2.5 ASSESSMENT OF RISK FROM SW UNAVAILABILITY

The overall objective of this assessment was to perform a probabilistic analysis of the SW system with particular emphasis on the change in the Unit 2 Core Damage Frequency induced by isolating each train of SW for periods of seven (7) days to install blocking devices. The analysis includes:

- o A reliability study of the North Anna Station SW System in normal operation (i.e. two main headers operable);

- o A reliability study of the SW System in an LCO condition with 168 hours (7 days) as the mission time;

- o Determination of the change in CDF as a result of SW System being in a LCO condition of seven (7) days duration.

The general procedure used to perform SW system fault tree analysis is outlined in HNUS General Task Procedure Task FT (Reference 8) with exceptions noted in the North Anna IPE task plan for system modelling (Reference 9). The starting point for the development of the fault tree models is obtained from the North Anna Power Station IPE (Reference 10). The NUPRA computer code (Reference 11) was used to generate the fault trees and to quantify these trees.

The major inputs and sources used for performance of the analysis are those used for the North Anna Power Station (NAPS) IPE. The IPE has used North Anna P&IDs (FM series drawings) to develop system flow paths, and the FE and ESK series drawings to determine power requirements. System descriptions were obtained from the various training manuals, vendor manuals, and the UFSAR. Additional information has been obtained during plant walkdowns, through the video disc information management system (VIMS), or directly from the system engineers at the plant. The North Anna operating procedures, abnormal procedures, emergency

procedures, functional restoration procedures, technical specifications, and testing and maintenance procedures were used to determine operational parameters.

The inputs from the other IPE tasks include the system success criteria from Task AS; the basic event unavailabilities and common cause failure probabilities from Task DB; and the human error probabilities from Task HI.

A detailed description of the SW system analysis is presented in Appendix C.

SECTION 3
RESULTS

The results of the PRA analysis of each of the areas of possible risk contribution are discussed in the following sections.

3.1 RISK CONTRIBUTION OF EXCAVATION DURING UNIT 1 OPERATION

During the excavation and backfill, the SW lines and overlaying cable ducts will be exposed to damage from construction mishaps or external event hazards. The IPE model was modified and used to determine the change in Unit 1 CDF in relation to the probability of damage to these structures. The details of these analyses are provided in Appendix B. The results are presented in figure 3.1 for the electrical ducts and figure 3.2 for SW lines.

The damage probability values shown in the figures represent the probability of damage to the electrical ducts or SW lines during the period that Unit 1 is in operation and the excavation is open. These curves were used to evaluate the CDF contribution of possible construction mishaps and external events. The evaluation results are discussed in the following sections.

3.1.1 Construction Mishaps

The results of the qualitative hazard assessment of the excavation and backfill activities are presented in Table 3.1. This table represents the possible hazards, causes, and preventive measures for each step in excavation and filling. The recommended preventive measures are summarized in Table 3.2. Many of these measures may be addressed by existing plant procedures. Other items would be included in project work plans. All items should be included in training and shift briefs of the work crews performing the excavation.

The only possibility of a mishap would result from failure of personnel to follow the administrative policies used to implement the measures described above. The "Handbook of

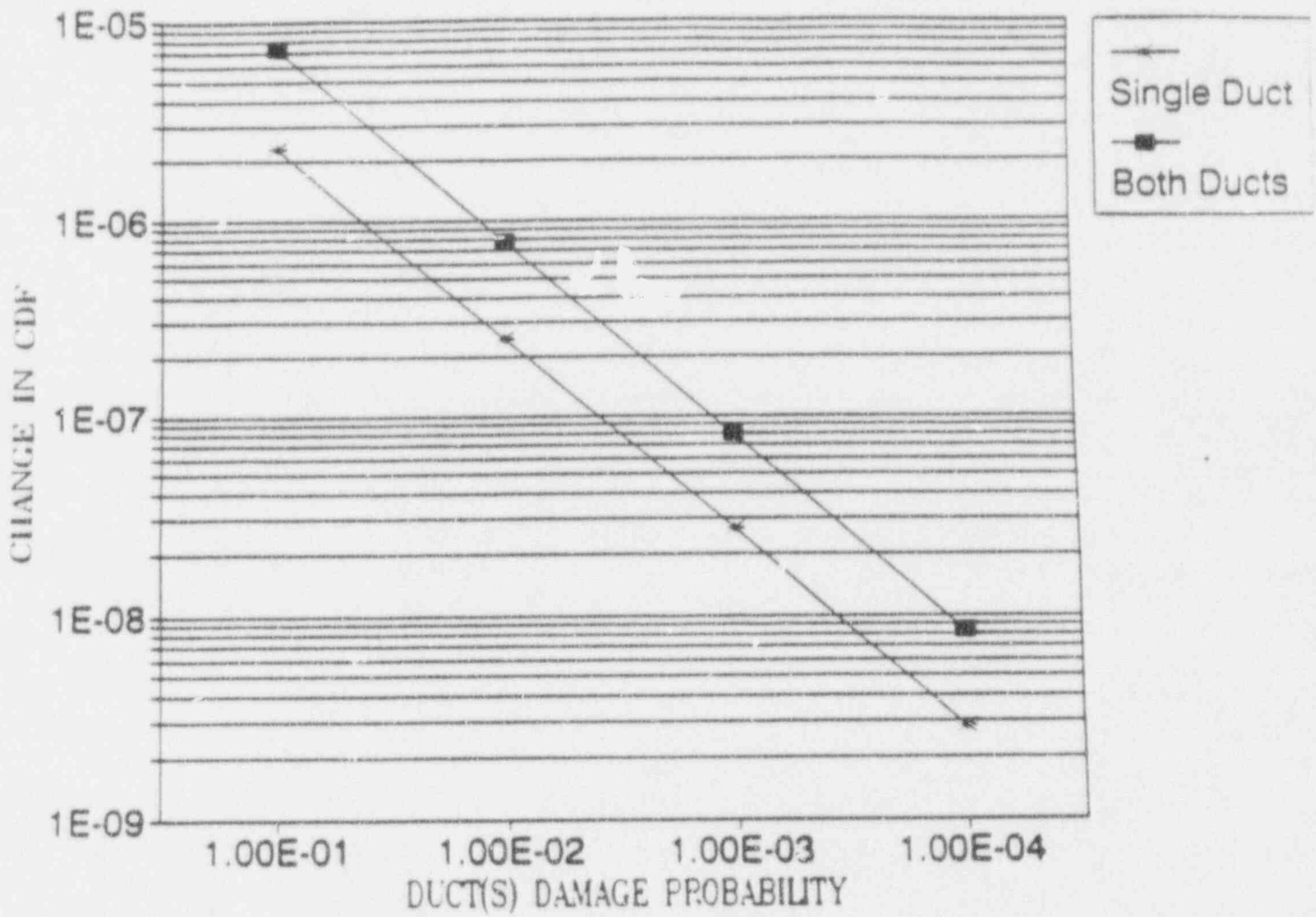


Figure 3.1: Increase in CDF in relation to Probability of Damage to Cable Ducts

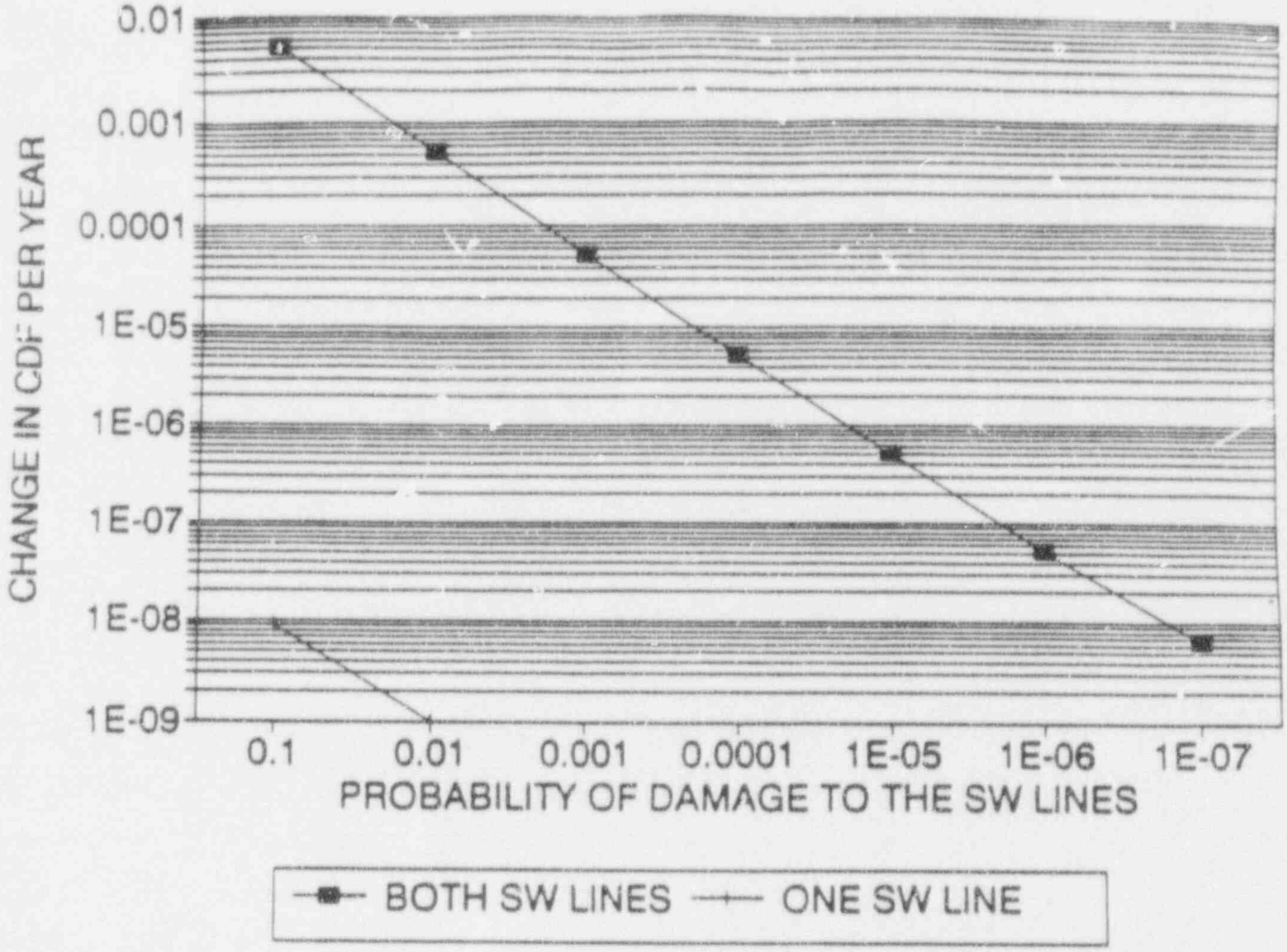


Figure 3.2: Increase in CDF in Relation to Probability of Damage to SW Lines

Table 3.1
Hazard Assessment of the Unit 1 SW Excavation and Backfill

Construction Steps	Possible Hazards	Causes	Preventative Measures
1. Removal of surface pavement with jackhammers and backhoe-loader. Top 18" to 24" of excavation.	Damage to unidentified buried utility.	Human Error* Inadequate data on buried utility lines	A. Research of pertinent engineering drawings (FEs, FMs, FPs). B. Visual inspection of the pertinent sections of the Main Steam Valve House and QSPH, for penetrations to ensure that there are no other utilities which can be at risk.
2. Machine excavation up to a point approximately 2 feet above the N&P electrical duct lines.	Damage to unidentified buried utility and/or electrical duct lines with backhoe and/or jackhammers.	Human Error* Inadequate data on buried utility and duct line location	C. Prior to removal of soil w/backhoe use steel bar probe or probes or scanning methods to sound out the unexcavated area.
3. Hand excavation to a point approximately 2 feet below the bottom of the service water pipes with conventional hand powered and manual pick and shovel tools.	Damage to electrical duct lines from hand tools. Dump truck or other large equipment falling into open excavation damaging or collapsing the duct lines and/or service water pipes. Damage resulting from equipment, barriers or construction materials being knocked into the open excavation.	Human Error* Equipment Failure	D. Provide protective barriers, of sufficient strength to prevent the largest vehicle anticipated for this work from falling into the excavation.

Table 3.1 Continued
Hazard Assessment of the Unit 1 SW Excavation and Backfill

	Construction Steps	Possible Hazards	Causes	Preventative Measures
				E. All non-essential equipment and construction materials shall be located away from the excavation to prevent them from falling into the excavation area. F. All equipment and barriers located adjacent to the excavation shall be securely anchored or tied down to prevent accidental movement into the excavation. G. Current vehicle and equipment safety inspection.
4.	Shoring of excavation installation of piles and lagging with truck mounted crane. Installation of supports for duct lines and service water pipes. The concept of installation of shoring or support of shoring was not developed at the time this analysis was performed. This is an unresolved concern.	Shoring failure, damage to duct lines or service water pipes. Damage to duct line and service water pipes due to dropping of materials used for shoring.	Inadequate design of shoring and supports for duct lines and service water pipes Improper installation of shoring and supports Human Error* Equipment Failure	H. Independent review of the design, analysis and construction documents for the excavation shoring and supports for the duct lines and service water pipes. I. QA and/or engineering inspection of all materials used for and installation inspection (construction oversight) of all shoring work and supports identified above.

Table 3.1 Continued
Hazard Assessment of the Unit 1 SW Excavation and Backfill

Construction Steps	Possible Hazards	Causes	Preventative Measures
4.			J. Design of supports for the duct lines, service water pipe, and installation of shoring should include provisions to prevent a progressive collapse of the supports and should also allow for multiple support damage with no affect to the supported elements. The shoring activities should be scheduled such that, installation of the shoring would take place prior to excavation of SW lines.
			K. Ensure only experienced trained personnel are assigned.
			L. Provide direct verbal communication, via dedicated radio if required, as well as visual communication between the equipment operators and the workmen responsible for placement and removal of materials.

Table 3.1 Continued
Hazard Assessment of the Unit 1 SW Excavation and Backfill

	Construction Steps	Possible Hazards	Causes		Preventative Measures
4.				M.	All slings, hooks, chains, cables and lifting devices used for transporting of materials into, out of and over the excavation shall be properly designed and rated for the maximum anticipated load they will be used for. These items should be inspected prior to each use.
5.	Duct lines will be supported between the full width of the excavation.	Collapse of duct line and damage to service water pipes due to improper engineering evaluation or original construction of the duct lines.	Human Error* Inadequate as-built information regarding the design and construction of the duct lines and service water pipes.	N.	Provide independant supports so that the exposed lines are supported by supports that meet all appropriate seismic acceptance criteria in the UFSAR.
6.	Backfilling operations, unloading of backfilling material with a concrete bucket and truck mounted crane.	Damage or collapse of duct line from misguided concrete bucket. Damage to duct lines from dropping of construction materials on the ducts.	Human Error* Equipment Failure	O.	Provide alternate method of backfilling such as a fixed conveyor for transporting of backfill material.

Table 3.1
Hazard Assessment of the Unit 1 SW Excavation and Backfill

Construction Steps	Possible Hazards	Causes	Preventative Measures
6.	Damage or collapse of duct lines and/or service water pipes from improper soil compaction below these items.		P. Provide geotechnical consultation for the proper materials, method of placement, compaction and testing of the backfill material. Provide QA and/or engineering inspection of all backfilling and soil compaction work.
	Fire or explosion	Improper use or handling of gas powered hand compactors and fuel.	Q. Gasoline for gas powered hand compactors should be stored a safe distance from the excavation. Provide restrictions on amount of gas or number of gas containers that can be brought within the excavated area.
			R. The affected work area should be identified and maintained as a no-smoking zone.
			See G, K, L, and M above.

- Human Error includes the following:
  - o Improperly trained personnel
  - o Inexperienced personnel (equipment operators)
  - o Inadequate communication between key personnel
  - o Sudden illness

TABLE 3.2

RECOMMENDED MEASURES FOR PREVENTION OF CONSTRUCTION MISHAPS

1. Review current drawings and adjacent walls for unidentified utilities.

2. Procedure to include manual probe for cable ducts.

3. Install barriers to prevent vehicles within ten feet of excavation.

4. Procedure and shift inspections to ensure loose materials not needed for work in progress are kept 50 feet from excavation area.

5. Use steel bar probes or other survey methods to sound out the unexcavated area.

6. Direct verbal or dedicated radio communication between construction equipment operators and supervisor/observer.

7. Administrative controls to ensure rigging equipment is properly selected and checked prior to each use.

8. Review procedures and work plans to ensure no possibility of lifting heavy loads over the exposed SW supply lines. A heavy load is a load which, if dropped, could puncture the SW line.

9. Securely anchor or tie down all equipment and barriers which must be adjacent to the excavation area. Keep all other equipment/materials sufficient distance from the excavation to eliminate possibility of missile hazards during high wind.

10. Perform Review of Design package and its analysis for installation of shoring and supports.

11. Perform QA and/or engineering inspection of all all pertinent shoring and temporary support materials.

12. Install the shoring at lower elevations before exposing the SW piping.

13. Provide appropriately qualified seismic supports for the duct lines during excavation.

14. All gas powered equipment should be refilled using small containers and number of containers brought within the excavation area should be restricted.

15. Delay excavation below the top of SW lines until several days prior to Unit 1 shutdown.

Human Reliability Analysis..." (Reference 12, table 20-6) provides a human error probability (HEP) value of 0.01 for errors in compliance with administrative controls. Clearly, only a small fraction of the violations would be expected to result in damage to the ducts or SW lines. However, the .01 value can be considered as a very conservative upper bound for the probability of damage to these structures from construction mishaps.

Using the .01 probability value with the curves in figures 3.1 and 3.2, the change in CDF is less than 1E-6 for all cases except the case of simultaneous damage to both SW supply lines. The probability of occurrence of this event must be less than 8E-6 in order to limit the change in CDF to less than 1E-6. The probability of a mishap resulting in simultaneous large ruptures to two SW lines can be minimized by the following measures:

- o Delay excavation of the SW lines until the last several days prior to the outage
- o Controls and frequent inspections to ensure that no heavy materials with dimensions in excess of 6 feet (the distance between SW lines) are in vicinity of the excavation after SW lines are excavated.

With these measures in place, the likelihood of a mishap which damages both SW supply lines is extremely remote and the increase in CDF would be less than 1E-6.

3.1.2 EXTERNAL EVENTS

The probability of occurrence during the excavation or fill period of external events which could damage the cable duct lines are shown in Table 3.3.

The probability of a seismic event is significant and cannot be screened out. The effect of a seismic event which damages the duct lines cannot be quantitatively assessed since a base case seismic PRA has not been completed for NAPS. This result indicates that the cable ducts should be supported to withstand seismic loads equivalent to the plant design basis.

TABLE 3.3

PROBABILITY OF EXTERNAL EVENTS DURING EXCAVATION/BACKFILL PERIOD

EVENT	ANNUAL FREQUENCY	PROBABILITY PER 60 DAYS
Earthquake 0.18g	0.4-2E-3	0.65-3.4E-4
Tornado	1-3.3 E-5	1.6 to 5.4 E-6

For high winds, the results indicate that the probability of occurrence is less than 6 E-6. The probability of damage to the structures from wind missiles is conservatively estimated to be 25 percent of this value (i.e., < 1.2 E-6). With this probability of damage for the cable ducts and SW lines, the increase in CDF is less than 1E-6 in all cases.

The results of the risk calculations for possible hazards to the SW lines and electrical ducts are summarized in Table 3.4. The results show that, given adequate seismic supports for the cable ducts, the increase in CDF and the probability of a core damage event during the excavation and backfill periods will be less than 1E-6.

Table 3.4: Increase in Probability of a Unit 1 CD Event During Excavation/Backfill

HAZARD	Probability of Occurrence During 60-days	Increase in Unit 1 CDF	Increase in Unit 1 Core Damage Probability
Construction Mishap Damages Cable Ducts	.01	3 E-7	3 E-9
Construction Mishap Damages One SW Line	.01	1 E-8	1 E-10
Construction Mishap Damages Two SW Lines	1 E-6	<3.E-7	3 E-7
Seismic Event (.18g) Damages Both Cable Ducts	3.4 E-4	Unknown	
Tornado Missile Damages Cable Ducts	1.25 E-6	<1E-9	<1E-9
Tornado Missile Damage One SW Line	1.25 E-6	<1E-9	<1E-9
Tornado Missile Damages Both SW Lines	<1E-6	<3E-7	3 E-7
Total		<1E-6	<1 E-6

3.2 SERVICE WATER UNAVAILABILITY

The results of fault tree analysis for the unavailability of the service water system for different cases are provided in Table 3.5. The change in the probability of core damage due to isolation of SW headers, Delta CD_{SWPP}, is given by:

$$\text{Delta } CD_{SWPP} = (\text{change in CDF per year}) * f$$

where

f = the additional fraction of the year that the SW system would be in one header operation.

$$f = (6*7)/365 = .12$$

$$\text{Delta } CD_{SWPP} = (4.4E\text{-}5) * .12 = 5.1E\text{-}6$$

Table 3.5

Contribution of SW Unavailability to Core Damage Probability

SW Configuration	Increase in Unit 2 CDF (Events/Year)	Increase in Core Damage Probability During 6 Periods
One Train Isolated	4.4 E-5	5.1 E-6
One Train Isolated, Capability for Emergency Pipe Repair	1.2 E-5	1.4 E-6
One Train Isolated, Capability for Bearing Cooling to HVAC Chiller	2.6 E-5	3.0 E-6
One Train Isolated, Capability for Pipe Repair and Bearing Cooling	6.5 E-6	7.4 E-7

These results show that isolation of the service water headers for the six times necessary to install and remove the blocking devices will increase the probability of a core damage event on Unit 2 by 5.1 E-6.

There are certain measures which would limit the increase in plant operational risk. These recommendations are listed below:

1) Provide cooling for the Unit 2 Emergency Switchgear Room (ESGR), in an event of total loss of SW system. One feasible option is to provide a temporary supply and return path to/from the Bearing Cooling System to the Unit 1 air conditioning chillers. (e.g., the Design Change Number 91-009-1, indicates that a temporary supply and return path to/from the Bearing Cooling system will be provided to maintain at least one Unit 1 chiller available). Implementation of this recommendation will allow credit to be taken for providing adequate cooling to the ESGR in the event of loss of SW.

2) Provide emergency pipe repair materials, trained personnel, and a procedure to repair the SW piping in the auxiliary building in an event of pipe rupture. This will allow the quick recovery from the loss of SW system due to pipe rupture. The frequency of T6 initiating event, when in one header operation, will be reduced.

The effectiveness of these measures in reducing the risk of a core damage event is illustrated in Table 3.5. The results show that if both measures are implemented, the increase in Unit 2 core damage probability because of SW unavailability is less than 1E-6.

SECTION 4

CONCLUSIONS AND RECOMMENDATIONS

A summary of the conclusions and recommendations resulting from the PRA are presented in this section.

4.1 CONCLUSIONS

The conclusion of the PRA analysis of the Unit 1 SW line restoration project is that project will not have a significant effect on the risk of a core damage event for Unit 1 or 2.

Performing the excavation and backfill activities while Unit 1 is operating will result in a negligible (< 1E-6) contribution to CDF and the probability of a Core Damage (CD) event occurring during these periods. This conclusion is based on the assumption that the cable ducts are seismically supported and appropriate measures are in place to prevent construction mishaps.

The probability of a construction mishap which would damage the cable ducts would have to be greater than 0.1 to have a significant effect on core damage probability. With the recommended preventive measures, the likelihood of a mishap of this type is conservatively estimated to be less than 0.01. Therefore, the probability of mishaps during excavation and filling will have no significant effect on risk.

External events other than earthquakes and tornadoes/high winds were qualitatively screened and it was determined that they have no or an extremely unlikely effect relevant to the project. The probability of a seismic event during the periods when Unit 1 is operating with the duct lines exposed was found to be significant. Therefore, the ducts will require supports designed to meet seismic qualification standards. The CD contribution of tornado/wind carried missile damage to the duct lines was found to be negligible.

The repeated isolation of service water headers for the purpose of installing and removing blocking devices will have a small effect (5.1 E-6) on the probability of a CD event for Unit 2. This effect is primarily from the sequence initiated by a total loss of SW and is dominated by the probability of a pipe rupture in the operating SW header. The analysis considered recovery measures to restore the SW header or provide cooling to critical components in Unit 2. These measures would further reduce the probability of a CD event during periods of operation with one SW header isolated to less than 1E-6.

4.2 RECOMMENDATIONS

It is recommended that the design package, work procedures, and worker training modules for the SW excavation and backfill tasks be carefully reviewed to ensure that the measures to prevent construction mishaps are fully addressed.

It is also recommended that the project include seismically qualified supports for the cable ducts. These supports should be installed as soon as possible after the duct is excavated.

It is also recommended that provisions for emergency repair of SW piping be established prior to isolation of the SW Header. The modification to provide Bearing Cooling System water as a backup cooling source for HVAC chillers should also be considered.

SECTION 5

REFERENCES

1. North Anna Power Station Technical Specifications.

2. Memorandum from E.L. Cooper, to A.V. Blankley, "IR-7006, Service Water Preservation Project - Phase 1, NAPS, 7/2/92.

3. M. P. Bohn, J. A. Lambright, Procedures for the External Event Core Damage Frequency Analyses for NUREG-1150, NUREG/CR-4840, U.S. Nuclear Regulatory Commission, Washington, D.C., November 1990.

4. D.L. Berneruter, et al., Siesmic Hazard Characterization of 69 Nuclear Plant Sites East of the Rocky Mountains, NUREG/CR-5250, October 1988.

5. Electric Power Research Institute, Probabilistic Seismic Hazard Evaluation for North Anna Power Station. North Anna Project RP-101-53, April 1989.

6 American Nuclear Society, "Standard for Estimating Tornado and Extreme Wind Characteristics at Nuclear Power Sites", ANSI/ANS 2.3-1983.

7. North Anna Power Station UFSAR

8. "Probabilistic Risk Assessment, General Task Procedure, Task FT, Systems Analysis," NUS Corporation, Rev. 0, March 21, 1989.

9. HNUS Project 0581 - Task 320M.N, Virginia Power Project NP-1498, Task Plan - System Modelling Task (SM), North Anna Units 1 and 2, Rev. 0, May 1991.

10. North Anna Probabilistic Risk Assessment for the IPE, to be Published.

11. VP-NE-760, "NUPRA Version 2.0 - PC-Based Software for Prob[illegible] Risk Analysis," NAF Virginia Power Technical Report, Rev. 0.

12. A. D. Swain, H. E. Guttmann, "Handbook of Human Reliability Analysis with Emphasize on Nuclear Plant Applications" NUREG/CR-1278, Sandia National Laboratory, Albuquerque, NM, 1983.

13. "Tornado Hazard to Class I Electrical Conduits at Pilgrim Nuclear Generating Station", BECO SUDDS No. 87-1023, December, 1987.

APPENDIX A

Appendix A

Functional Identification of Cables

The affected systems are identified by the functional identification of cables inside duct lines P and N. A list of all the cables in the N and P duct lines were prepared to analyze the consequence of the damage to the duct lines. The analysis is conducted in several steps, including:

i) Review of the cables to screen out, based on the system designators, non risk contributing cables.

ii) Identification of the origin (FROM) and the destination (TO) of all the remaining cables.

iii) Identification of the Loads (Affected Components). Using the data banks, and pertinent engineering drawings (FEs, ESKs, as well as loop diagrams), the affected components were identified.

iv) The list of the affected components were analyzed No component (or group of components) failures which would result in an initiating event (plant trip, either manual or automatic) is identified. Accident mitigating components which could be disabled (made functionally unavailable) as a result of the cable damage include:

> Two outside recirculation spray pumps, two motor-driven Auxiliary Feedwater (AFW) pumps, and two Low Head Safety Injection (LHSI) pumps.

The complete list is provided in Table A-1. The key for system designators codes, and equipment mark numbers are provided in the general nuclear standard (STD-GN-008). Items in parentheses are the pertinent references. A complete description of the reference is provided in Table A-2, and a full description of the type designators is provided in Table A-3.

TABLE A-1: UNIT 1 DUCTS ASSOCIATED WITH SERVICE WATER
REPAIRS (SERVICE BUILDING-QUENCH SPRAY EXCAVATION)
PHASE 1 AFFECTED CABLES

DUCT LINE N

1DK008OA1

CABLE NUMBER	FROM	TO	AFFECTED COMPONENT	COMMENTS
1MSSANK001	SPARE DUCT	(NCABLE)		TYPE 1
1MSSCNK001	SPARE DUCT	(NCABLE)		TYPE 1
1QSSNNK001	1-EP-CB-48A	LS-QS103	UNIT 1 RWST TANK	TYPE 3- THE ABILITY TO MONITOR RWST MAY BE LOST.
1SWEAOK100	1-EP-CB-19A	JB-730 (ATTACH. 1)	SOV-SW101A-1 (11715-SW-037) AND TV-SW101A	TYPE 3- LOSS OF THIS CABLE WILL RENDER SOV-SW101A-1 INOPERABLE. AS A RESULT TV-SW101A CANNOT BE OPENED IF NEEDED.
1SWEBOK100	1-EP-CB-80A	JB-740 (ATTACH. 1)	SOV-SW101B-1 (11715-SW-038) AND TV-SW101B	TYPE 3- LOSS OF THIS CABLE WILL RENDER SOV-SW101A-1 INOPERABLE. AS A RESULT TV-SW101A CANNOT BE OPENED IF NEEDED.

1DH007OA1

CABLE NUMBER	FROM	TO	AFFECTED COMPONENT	COMMENTS
1RSOAOH001	1-EE-SW-01-H10	1-RS-P-02A (ATTACH. 1)	1-RS-P-02A (FE-8BM)	MOTOR FOR 1-RS-P-02A WILL BE MADE UNAVAILABLE.

1DH007OA2

CABLE NUMBER	FROM	TO	AFFECTED COMPONENT	COMMENTS
1FWEAOH001	1-EE-SW-01-H3	1-FW-P-03A (ATTACH. 1)	1-FW-P-03 (FE-8BE)	MOTOR FOR 1-FW-P-03 WILL BE MADE UNAVAILABLE.

1DH007OA3

CABLE NUMBER	FROM	TO	AFFECTED COMPONENT	COMMENTS
1SILAOH001	1-EE-SW-01-H9	1-SI-P-01A (ATTACH. 1)	1-SI-P-01A (FE-8BL)	MOTOR FOR 1-SI-P-01A WILL BE MADE UNAVAILABLE

CABLE NUMBER	FROM	TO	1DC007OA2 AFFECTED COMPONENT	COMMENTS
1HHANNC458		(ATTACH. 1)		TYPE 4

CABLE NUMBER	FROM	TO	1DC007OA2 AFFECTED COMPONENT	COMMENTS
1SILNNC010	1-EI-CB-48A	JB-1172 (NCABLE)	MC[illegible]1862A (FE-46L)	TYPE 3- ASSUME MOV 1862A WILL BE DISABLED. THE MOV IS NORMALLY OPEN AND IS ON THE RWST SUPPLY LINE TO 1-SI-P-IA (FM 96A 1 OF 3)
1SISNOC210	1-EI-CB-05-AER	JB-639 (ATTACH. 1)	SOV-SI1859 (SI-035) (TV-1859)	TYPE 3- SOV-1859 WILL REMAIN CLOSED, NOT ALLOWING TV-1859 TO OPEN.

CABLE NUMBER	FROM	TO	1DC007OA2 AFFECTED COMPONENT	COMMENTS
1MSBAOC051	1-EI-CB-05-AEN	JB-1130 (ATTACH. 1)	SOV-MS113A-1 (MS-117) (TV-MS113A)	TYPE 3- SOV-MS113A-1 WILL BE LEFT UNENERGIZED, CAUSING TV-MS113A TO REMAIN CLOSED.
1MSBAOC115	1-EI-CB-05-AEQ	JB-[illegible]4 (ATTACH. 1)	SOV-MS109A (MS-113) TV-MS109	TYPE 3- LOSS OF THIS CABLE WILL RESULT IN LOSS OF SOV-109A WHICH IN TURN WILL NOT ALLOW TV-SW109 TO OPERATE IF NEEDED.
1MSBAOC315	1-EI-CB-05-AER	JB-602A (ATTACH. 1)		TYPE 1- SPARE (FE-46K)
1MSBBOC051	1-EI-CB-05-AEN	JB-1131 (ATTACH. 1)	SOV-113B-1 (MS-118)	SOV-MS11[illegible] WILL REMAIN CLOSED (UNENERGIZED), NOT ALLOWING TV-MS113B TO OPEN.
1MSBCOC051	1-EI-CB-05-AER	JB-1132 (ATTACH. 1)	SOV-MS113C-1 (MS-119)	SOV-MS118-1 WILL REMAIN CLOSED (UNERGIZED, NOT ALLOWING TV-MS113C TO OPEN.
1MSSAOC315	1-EI-CB-05-AEP	JB-615A (ATTACH. 1)	TV-MS101A-1 (MS-110)	SOV-101A-1 WILL BE DE-ENERGIZED, NOT ALLOWING TV-MS113A TO OPEN.
1MSSBOC315	1-EI-CB-05-AEP	JB-617A (ATTACH. 1)	TV-MS101B-1 (MS-111)	SOV-MS101B WILL BE LOST. THE ABILITY TO CLOSE TV-MS101B WILL BE DEGRADED.
1MSSCOC315	1-EI-CB-05-AEP	JB-619A (ATTACH. 1)	TV-MS101C-1 (FE-112)	SOV-MS101C-1 WILL BE LOST. THE ABILITY TO CLOSE TV-MS101B WILL BE DEGRADED.

CABLE NUMBER	FROM	TO	AFFECTED COMPONENT	COMMENTS
			1DC007OA2	
1HVRNNC052	COILED	(NCABLE)		TYPE 2
1SVSNOC115	1-EI-CB-05-AEP	JB-609 (ATTACH. 1)	TV-SV102A-1 (FE-460)	SOV-SV102-2 CANNOT BE ENERGIZED, NOT ALLOWING TV-SV102-2 TO OPEN.
1SVSNOC131	1-EI-CB-05-AEN	JB-609 (ATTACH. 1)	TV-SO102A-1 (FE-460)	DISABLES LS FOR TV-SV102-2 (NO TESTS ARE ALLOWED)
1SWEAOC100	JB-730	1-EI-CB-07	SOV-SW-101A-1 (FE-3CF)	POSITION INDICATION LIGHTS ON THE TEST PANEL WILL BE LOST. OPERABILITY OF THE SOV WILL NOT BE AFFECTED.
1SWEBOC100	JB-740	1-EI-CB-07	SOV-SW-101B-1 (FE-3CF)	POSITION INDICATOIN LIGHTS ON THE TEST PANEL WILL BE LOST. OPERABILITY OF THE SOV WILL NOT BE AFFECTED.
			1DX007NB1	
1IHANNX810				TYPE 4
1RMSNNX001				-
1RMSNNX002				-
1RMSNNX003				-
1RMSNNX007				-
1RMSNNX021				-
1RMSNNX022				-
1RMSNNX023				-
1RMSNNX027				-
1MSSFNX001	1-EI-CB-44	FT-MS105 (NCABLE)	NEAR 1-FW-P-2 (FE-46R)	ASSUME FLOW TRANSMITTER IS DISABLED
1FWSNNX820	FE-74, T, W	JB-1014 (NCABLE)	PCV-FW 159A (FW-053)	ABILITY TO MEASURE AFW DISCHARGE PRESSURE IS DEGRADED.

DUCT LINE P

1DH007PB1

CABLE NUMBER	FROM	TO	AFFECTED COMPONENT(S)	COMMENTS
1RSOBPH001	1-EE-SW-02-J10	1-RS-P-02B (ATTACH. 1)	1-RS-P-02B (FE-8BY)	MOTOR FOR 1-RS-P-02B WILL BE LOST.

1DH007PB2

CABLE NUMBER	FROM	TO	AFFECTED COMPONENT(S)	COMMENTS
1FWEBPH001	1-EE-SW-02-J3	1-FW-P-03B (ATTACH. 1)	1-FW-P-03B (FE-8BR)	MOTOR FOR 1-FW-P-03B WILL BE LOST.

1DH007PB3

CABLE NUMBER	FROM	TO	AFFECTED COMPONENT	COMMENTS
1SILBPH001	1-EE-SW-02-J9	1-SI-P-01B (ATTACH. 1)	1-SI-P-01B (FE-8BX)	MOTOR FOR 1-SI-P-01B WILL BE LOST.

1DX001WA1

CABLE NUMBER	FROM	TO	AFFECTED COMPONENT	COMMENTS
1RSOBWX001	1-EI-CB-23B	LT-RS103A (ATTACH. 1)	1-RS-TK-1 (RS-29)	ABILITY TO MONITOR THE LEVEL OF CASE COOLING TANK 1-RS-TK-1 WILL BE DEGRADED.
1RSOBWX002	1-EI-CB-23B	TE-RS100A (ATTACH. 1)	(RS-31)	ABILITY TO MONITOR THE TEMPERATURE OF THE CASE COOLING TANK 1-RS-TK-1 WILL BE DEGRADED.

1DX001YA1

CABLE NUMBER	FROM	TO	AFFECTED COMPONENT	COMMENTS
1RSODYX001	1-EI-CB-23D	LT-RS103B (ATTACH. 1)	1-RS-TK-1 (RS-30)	ABILITY TO MONITOR THE LEVEL OF CASE COOLING TANK 1-RS-TK-1 WILL BE DEGRADED.
1RSODYX002	1-EI-CB-23D	TE-RS100B (ATTACH. 1)	1-RS-TK-1 (RS-32)	ABILITY TO MONITOR THE TEMPERATURE OF THE CASE COOLING TANK WILL BE DEGRADED.

CABLE NUMBER	FROM	TO	1DC007PB2 AFFECTED COMPONENT	COMMENTS
1HANNC459				TYPE 4
1HANNC493				TYPE 4
1RHSANC002	1-EE-SW-01-H14	1-EP-CB-84A1 (NCABLE)	1-RH-P-01 (FE-9HK)	TYPE 3- SWITCH FOR 1-RH-P-01A MOTOR HEATER
1SILANC004	1-EE-SW-01-H9	1-EP-CB-84A1 (NCABLE)	1-SI-P-01A (FE-9HK)	TYPE 3- SWITCH FOR 1-SI-P-01A MOTOR HEATER

CABLE NUMBER	FROM	TO	1DC007PB2 AFFECTED COMPONENT	COMMENTS
1RSOANC007	1-EE-SW-01-H10	1-EP-CB-84A	1-RS-P-02A (FE-9HF)	SWITCH FOR 1-RS-P-02A MOTOR HEATER.
1QSS7NC018	JB-520	1-EP-CB-28	1-RS-P-2A, 1-QS-P-2B (QS-14)	ONE OF THE CONTACTS FOR RWS TANK CHILLER PUMPS WILL BE LOST.
1HVRANC003	1-EE-SS-01-H7	1-EP-CB-84A (NCABLE)	1-HV-F-01C (FE-9HF)	SWITCH FOR 1-HV-F-01C MOTOR HEATER.
1HVRANC005	1-EE-SS-02-J7	1-EP-CB-84A (NCABLE)	1-HV-F-01C (FE-9HF)	SWITCH FOR 1-HV-F-01C MOTOR HEATER.
1HVRNNC062	COILED	(NCABLE)		TYPE 2
1FWEANC008	1-EE-SW-01-H3	1-EP-CB-84A (NCABLE)	1-FW-P-03A (FE-9HF)	SWITCH FOR 1-FW-P-03A MOTOR HEATER.
1FWEBNC008	1-EE-SW-02-J3	1-EP-CB-84B (NCABLE)	SPARE (FE-9HF)	

Table A-2
Complete Description of the References

Reference Code		Full Description
1 -	Attach. 1	Attachment 1 to the Memorandum from E.L. Cooper to R.W. Riley, February 24, 1992.
2-	NCABLE	North Anna Power Station Circuit Schedule, Cable Routing System.
3-	FE-XXXX	11715-FE-XXXXX, Engineering Drawing Number.

Table A-3
Complete Description of Type Designators

Cable Type	Full Description
Type 1	Spare Cables (Do not provide service, presently)
Type 2	Coiled Cables (Do not provide Service presently)
Type 3	Provide service and cannot be screened out based on system designator
Type 4	Provide service but is screened out based on system designator

APPENDIX B

Appendix B

General Methodology For Finding The Change
In CDF Due To Construction Mishaps

B-1 General Methodology

The change in core damage frequency (CDF) was calculated using the NAPS IPE. The NAPS IPE was performed using the NUPRA software system, developed by the Halliburton NUS Environmental Corporation. NUPRA is a PC-based user friendly safety/Reliability workstation for probabilistic risk/safety assessments (PRA/PSA).

The methodology used to perform the IPE for North Anna Power Station Units 1 and 2 is based on the performance of a Level 1 PRA. The approach used for the plant models is based on the use of event trees to develop the sequence of events following a plant transient or loss-of-coolant accident (LOCA), and fault trees to model the system failures and successes at each phase of the sequence. Each individual sequence is quantified by linking together the fault trees for the system and support system failures that lead to a given sequence of events. Each sequence defines a set of conditions leading to inadequate cooling of the core. The core damage frequency is then calculated by adding all the sequences which result in core damage.

The change in CDF was calculated by first establishing the base case CDF. The base case CDF was calculated by quantifying the NAPS IPE models that existed as of June 3, 1992. Then, the IPE models were modified to account for the mishaps during the SW Preservation Project. The modified IPE models were quantified to obtain the new CDF. The difference between the two CDF values represents the increase in risk due to construction mishaps. There are two distinct contributions from the construction mishaps to the increase in CDF. The first contribution is as a result of damage to the cable duct line(s) and the second is as a result of damage to the SW line(s). The evaluation of the change in CDF due to damage to duct line(s) and SW pipe line(s) failure is discussed in section B-2 and B-3 respectively.

B-2 Change in CDF due to Duct Line(s) Failure

The specific steps performed in finding the change in CDF during the construction period of interest (60 days) are as follows:

1. The IPE model, existed as of June 3, 1992, was quantified to establish the base case CDF.

2. The IPE model was modified to account for mishaps during construction. Specifically, the Auxiliary Feed Water (AFW), Low Head Safety Injection (LHSI), and Outside Recirculation Spray (ORS) fault trees were modified by adding the failure of Ducts N and P independently or by common cause to the failure of relevant pump branches. For example, the LHSI fault tree was modified by adding the FWLHRS-CC-1PUMPS and FWLHRS-SF-1APUMP basic events to the train A failure branch. This means that, in addition to other pump failure modes, the LHSI train A pump can also fail due to failure of the Duct line N or due to the common cause failure of both Ducts (N and P) during the construction period (see Figure B-1). The train B of the LHSI pump is modified in the same manner.

3. All newly added basic events (FWLHRS-CC-1PUMPS, FWLHRS-SF-1APUMP, and FWLHRS-SF-1BPUMP) were set to 0.1 in the Basic Event Data (BED) file. This was performed to ensure that most cutsets with newly added basic events are preserved by being above the truncation value.

4. All fault trees were updated from the BED file.

5. Re-solved the entire IPE model. The following steps were followed:

    a. Fault trees were linked together using Table 7A of the NAPS Quantification Analysis File.

b. Updated the linked trees based on relevant house event BED and then solved for the appropriate gates. The truncation values used for solving each top event unavailability were based on Table 7A

c. The merge control files or OCLs, which quantifies each individual accident sequences, were solved.

d. The Sequence probability or SEQ file, which contains records for the non-OK sequences in the event trees, was updated from the newly solved cut set equations assigned to the functional events challenged in the sequence.

e. The concatenation and truncation of all sequence cutset, which is the ANDing together of all the core melt sequence equations into a single plant damage equation, was performed.

f. A sensitivity analysis on the plant damage equation was performed to assess the impact of variations of single and both Duct failure probabilitie to the core damage frequency.

g. The change in CDF for various duct failure probabilities during the construction period was calculated. The change in CDF equals the CDF calculated in step 1 minus the CDF calculated in step 5e, the result of which was plotted on a logxlog scale (see Figure 3-1).

B-3 Change in CDF due to SW Line(s) Failure

The excavation of the SW lines during the construction process, will expose the lines to construction hazards. The SWPP PRA results indicate that the change in core damage frequency due to loss of SW (when in one header operation) during an accident is negligible. On the other hand, loss of both SW header during an accident, caused by construction mishaps, is considered to be insignificant, based on the assumption that if an accident would occur, the construction activities will be stopped. Thus only change in CDF due to total loss of SW during normal operation of the plant (ie no accident) is evaluated here. To quantify the change in CDF due to consequence of the construction hazard (construction mishaps) on the availability of the SW system, the following steps were taken:

1) The fault tree for the loss of SW initiating event frequency (T6) was modified to account for the probability (P_R) of the SW header(s) rupture due to construction mishaps. The T6 fault tree was then requantified to obtain the new Initiating Event (IE) frequency (f^{new}_{T6}).

2) Based on the new T6 IE frequency, the contribution of the T6 to the CDF was evaluated by requantification of the T6 event tree (C^{CDF}_{T6}).

3) The change in CDF was then obtained by subtraction of the contribution of the IPE T6 initiating event to the base case CDF, C^{CDF}_{BASE}, from the C^{CDF}_{T6}.

The above evaluations were performed for different values of P_R. The results of the quantification is presented in Figure B-2, and the modified fault trees for T6 initiating event frequency given damage to one or both headers are shown in Figures B-3 and B-4 respectively. It should be noted that during two header operation (if hazard from construction activities are not considered) the probability of header rupture is considered to be insignificant.

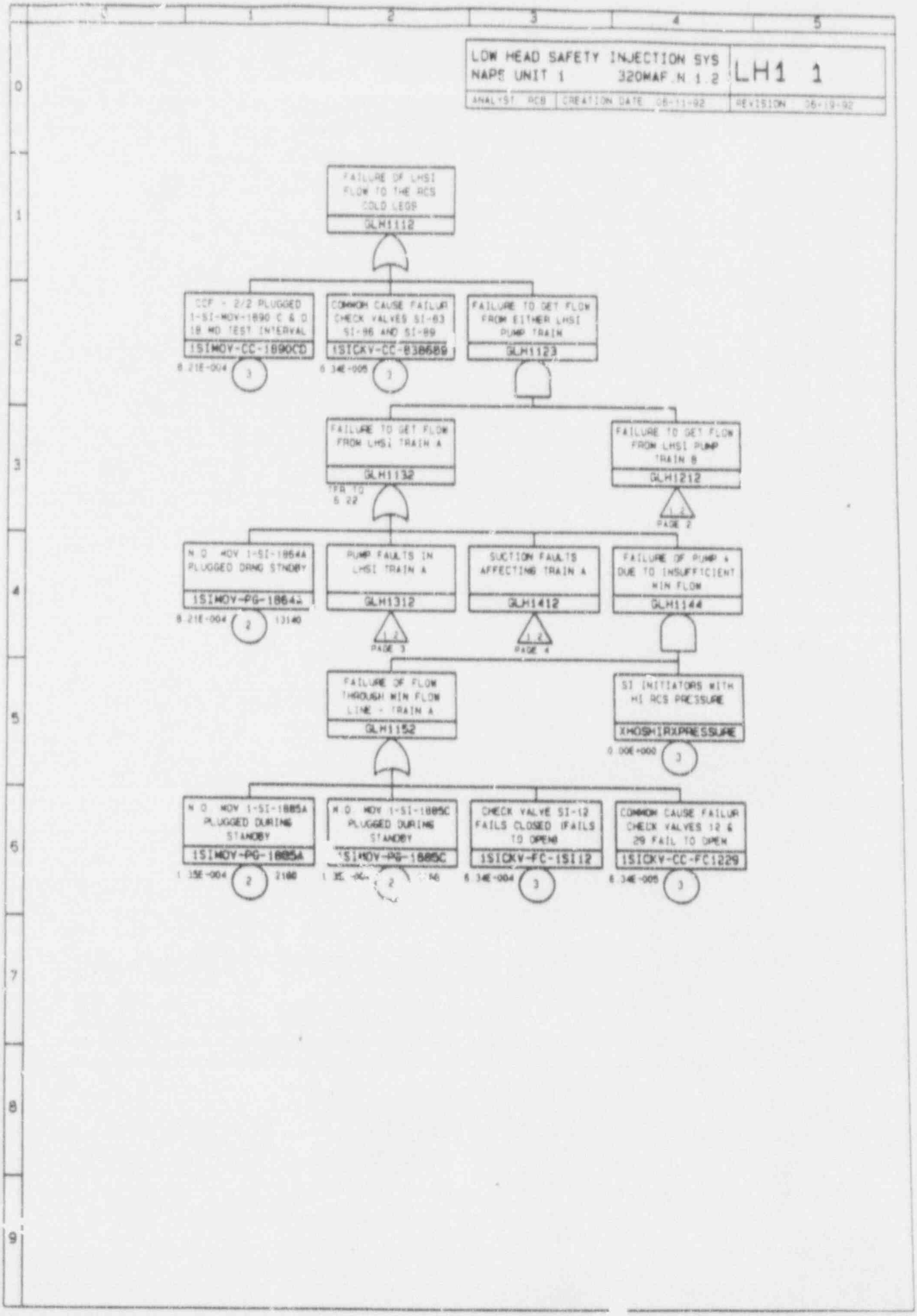
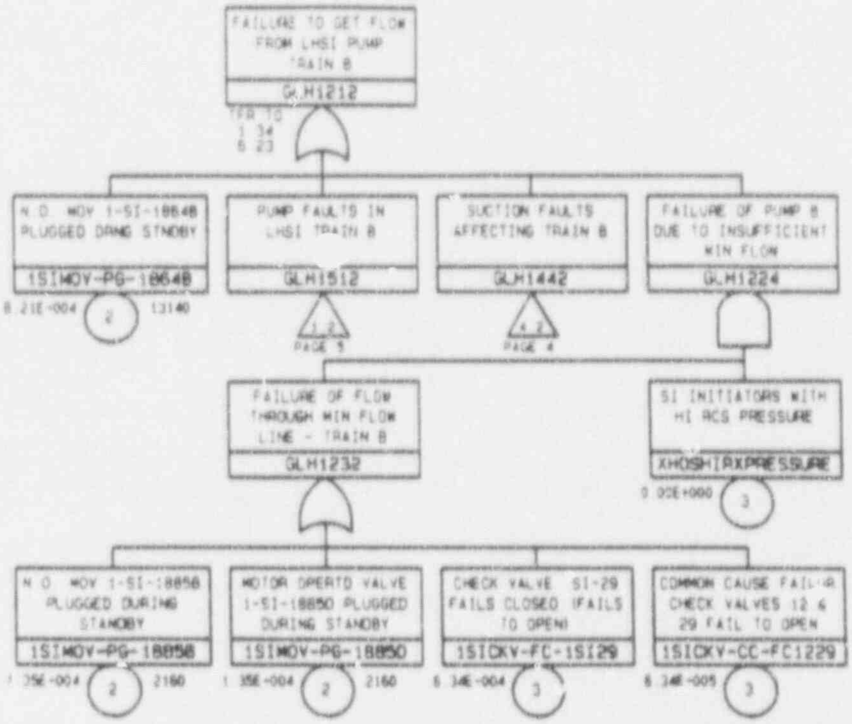


Figure B-1 Modified LHSI Fault Tree

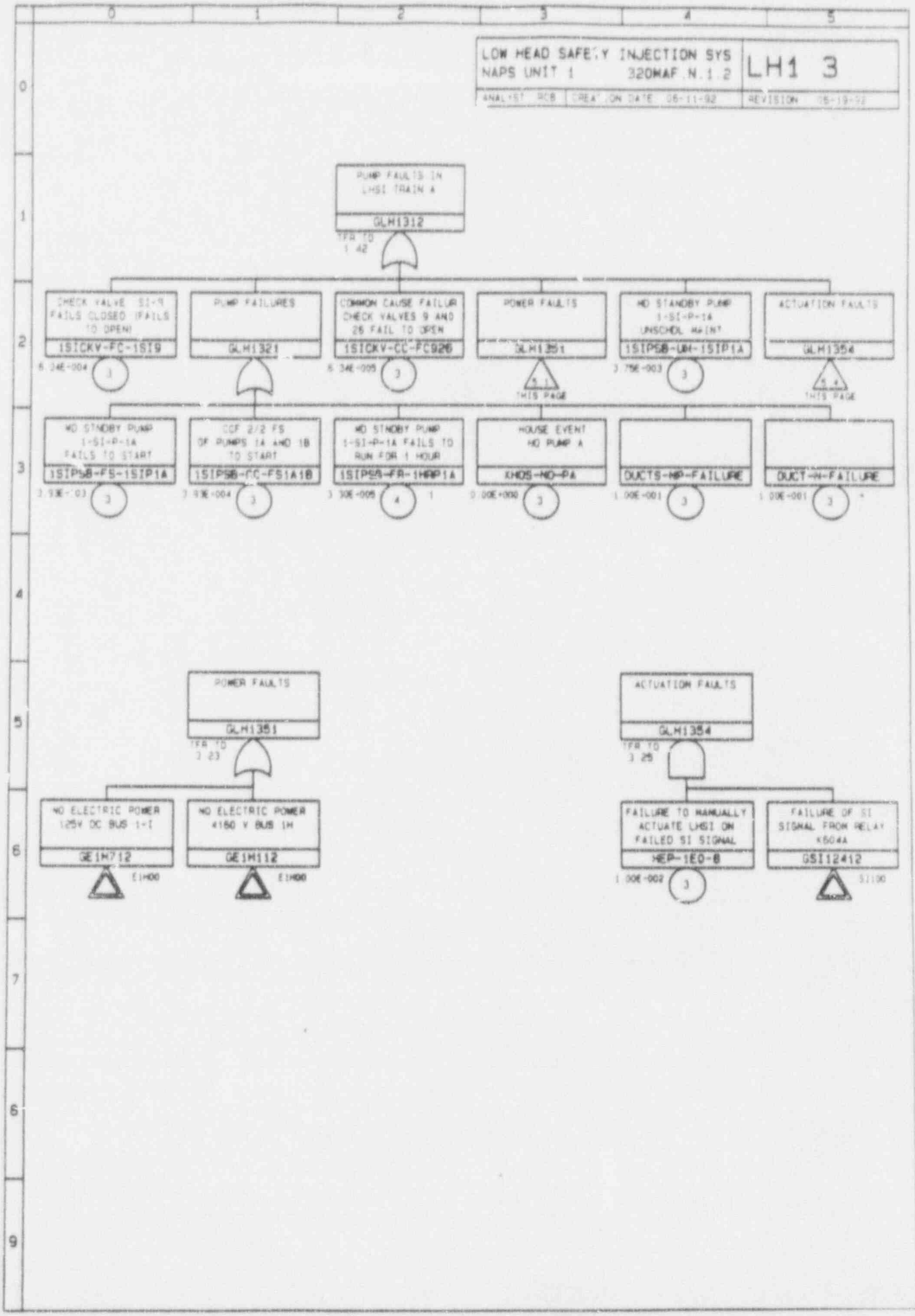
LOW HEAD SAFETY INJECTION SYS
NAPS UNIT 1 320MAF.N.1.2

LH1 2

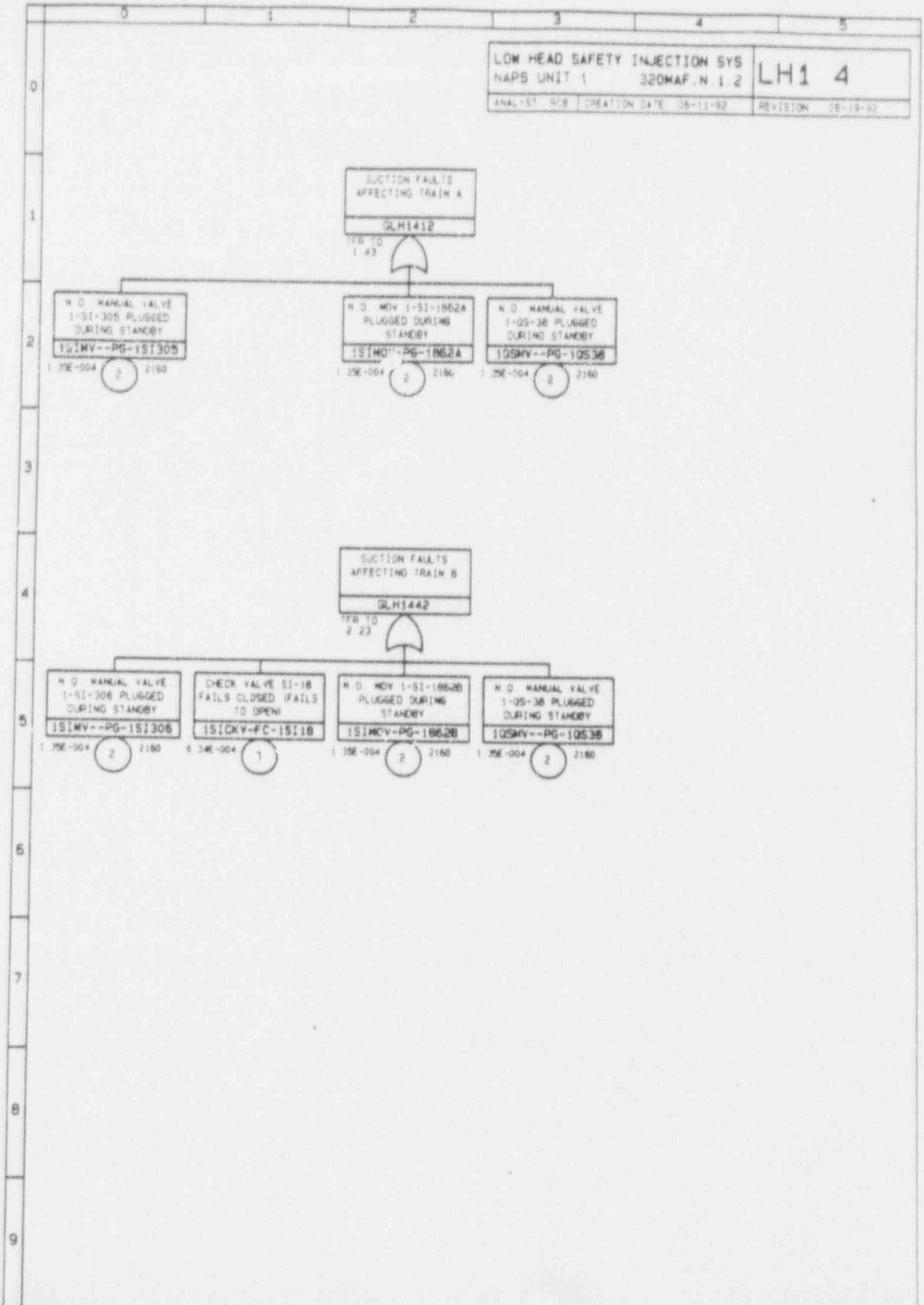
ANALYST: RCB | CREATION DATE 06-11-92 | REVISION 06-19-92



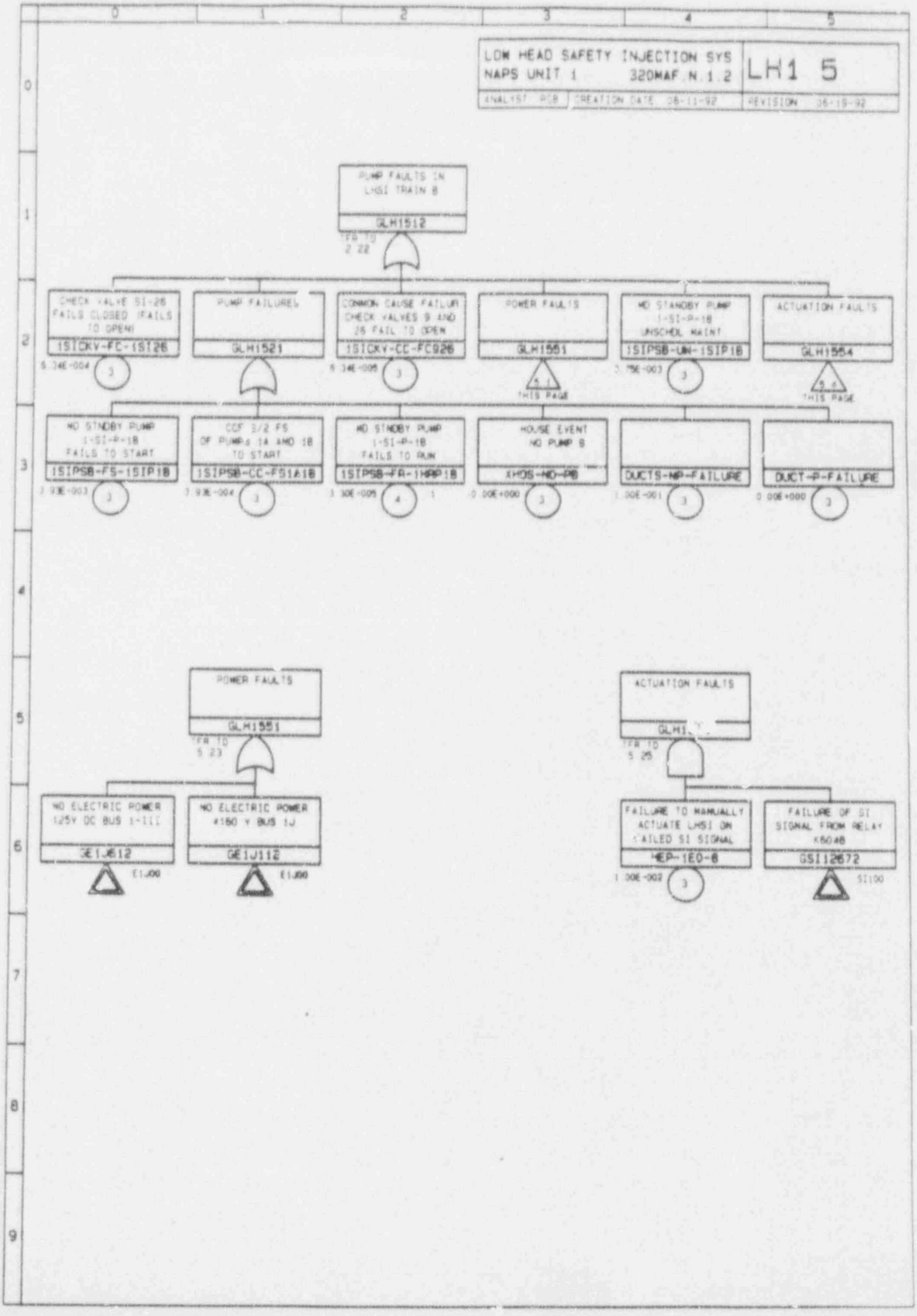
LH100 LGC NUPRA 2.0 HMMS ...



LOW HEAD SAFETY INJECTION SYS
NAPS UNIT 1
320MAF.N.1.2
LH1 3
ANALYST RCB
CREATION DATE 05-11-92
REVISION 05-19-92
PUMP FAULTS IN LHSI TRAIN A
GLH1312
TFR TO 1 42
CHECK VALVE SI-9 FAILS CLOSED (FAILS TO OPEN)
1SICKV-FC-1SI9
PUMP FAILURES
GLH1321
COMMON CAUSE FAILUR CHECK VALVES 9 AND 26 FAIL TO OPEN
1SICKV-CC-FC926
POWER FAULTS
GLH1351
MD STANDBY PUMP 1-SI-P-1A UNSCHDL MAINT
1SIPSB-UM-1SIP1A
ACTUATION FAULTS
GLH1354
THIS PAGE
MD STNDBY PUMP 1-SI-P-1A FAILS TO START
1SIPSB-FS-1SIP1A
CCF 2/2 FS OF PUMPS 1A AND 1B TO START
1SIPSB-CC-FS1A1B
MD STNDBY PUMP 1-SI-P-1A FAILS TO RUN FOR 1 HOUR
1SIPSB-FR-1HRP1A
HOUSE EVENT MD PUMP A
XHOS-MD-PA
DUCTS-MP-FAILURE
DUCT-N-FAILURE
POWER FAULTS
GLH1351
TFR TO 3 23
NO ELECTRIC POWER 125V DC BUS 1-I
GE1H712
NO ELECTRIC POWER 4160 V BUS 1H
GE1H112
E1H00
ACTUATION FAULTS
GLH1354
TFR TO 3 25
FAILURE TO MANUALLY ACTUATE LHSI ON FAILED SI SIGNAL
HEP-1EO-8
FAILURE OF SI SIGNAL FROM RELAY K504A
GSI12412
1.00E-002



LH100.LGC NUPRA 2.0 NAUS Env



LOW HEAD SAFETY INJECTION SYS
NAPS UNIT 1 320MAF.N.1.2
LH1 5
ANALYST: RGB
CREATION DATE: 06-11-92
REVISION: 06-19-92
PUMP FAULTS IN LHSI TRAIN B
GLH1512
CHECK VALVE SI-26 FAILS CLOSED (FAILS TO OPEN)
1SICKV-FC-1SI26
5.34E-004
PUMP FAILURES
GLH1521
COMMON CAUSE FAILUR CHECK VALVES 9 AND 26 FAIL TO OPEN
1SICKV-CC-FC926
POWER FAULTS
GLH1551
THIS PAGE
MD STANDBY PUMP 1-SI-P-1B UNSCHED MAINT
1SIPSB-UN-1SIP1B
ACTUATION FAULTS
GLH1554
THIS PAGE
MD STNDBY PUMP 1-SI-P-1B FAILS TO START
1SIPSB-FS-1SIP1B
CCF 2/2 FS OF PUMPs 1A AND 1B TO START
1SIPSB-CC-FS1A1B
MD STNDBY PUMP 1-SI-P-1B FAILS TO RUN
1SIPSB-FR-1HRP1B
HOUSE EVENT NO PUMP B
XHOS-NO-PB
DUCTS-NP-FAILURE
1.00E-001
DUCT-P-FAILURE
0.00E+000
POWER FAULTS
GLH1551
NO ELECTRIC POWER 125V DC BUS 1-III
GE1J612
E1J00
NO ELECTRIC POWER 4160 V BUS 1J
GE1J112
E1J00
ACTUATION FAULTS
FAILURE TO MANUALLY ACTUATE LHSI ON FAILED SI SIGNAL
HEP-1EO-8
1.00E-002
FAILURE OF SI SIGNAL FROM RELAY K604B
GSI12672
SI100

LOW HEAD SAFETY INJECTION SYS
NAPS UNIT 1 320MAF.N.1.2

LH1 6

ANALYST: RCB | CREATION DATE: 06-11-92 | REVISION: 05-19-92

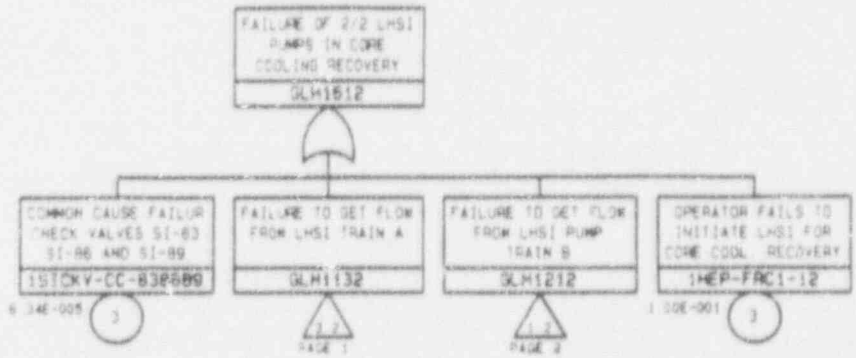
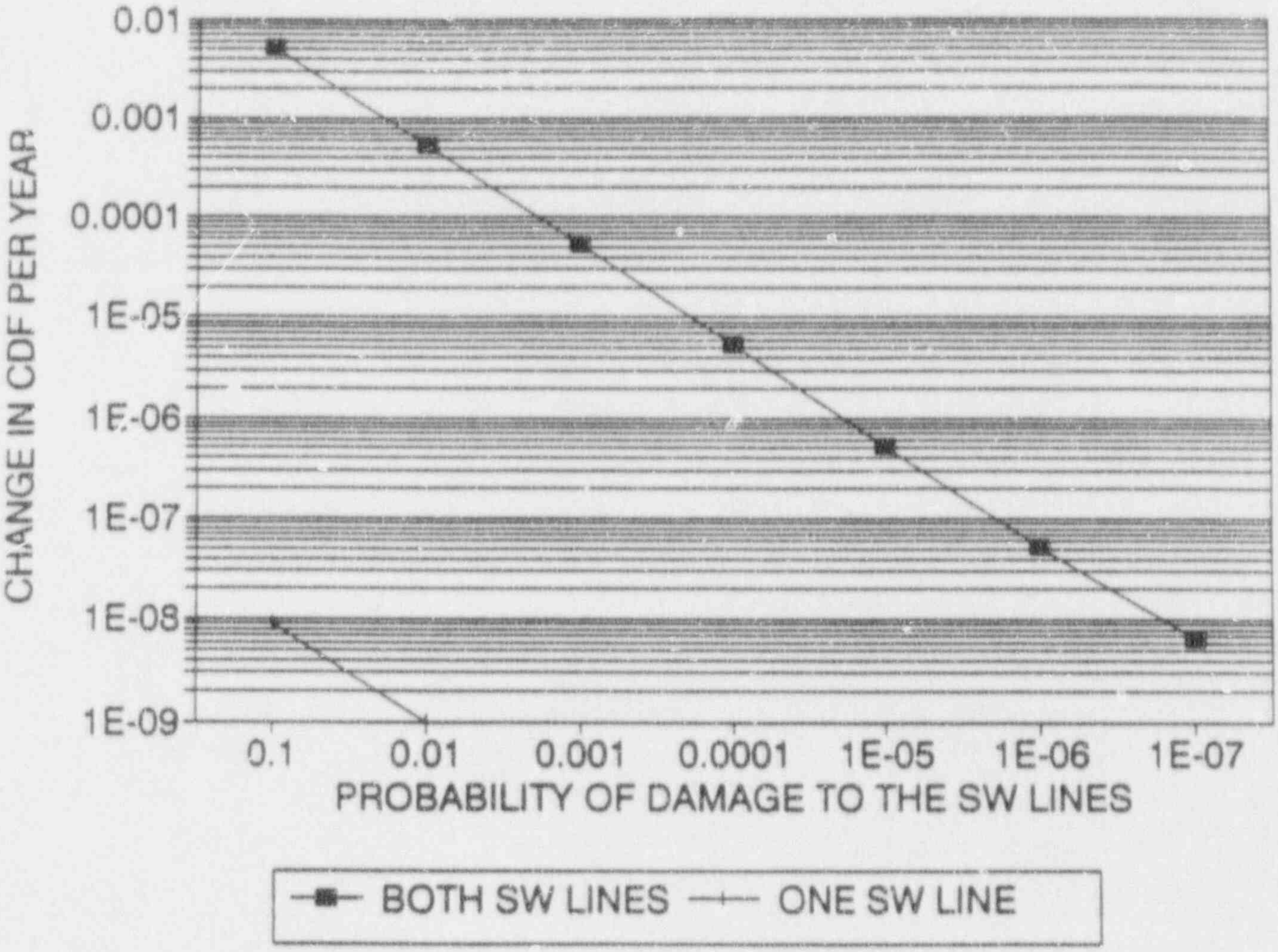


FIGURE B-2: CHANGE IN CDF VS PROBABILITY OF DAMAGE TO SW LINES



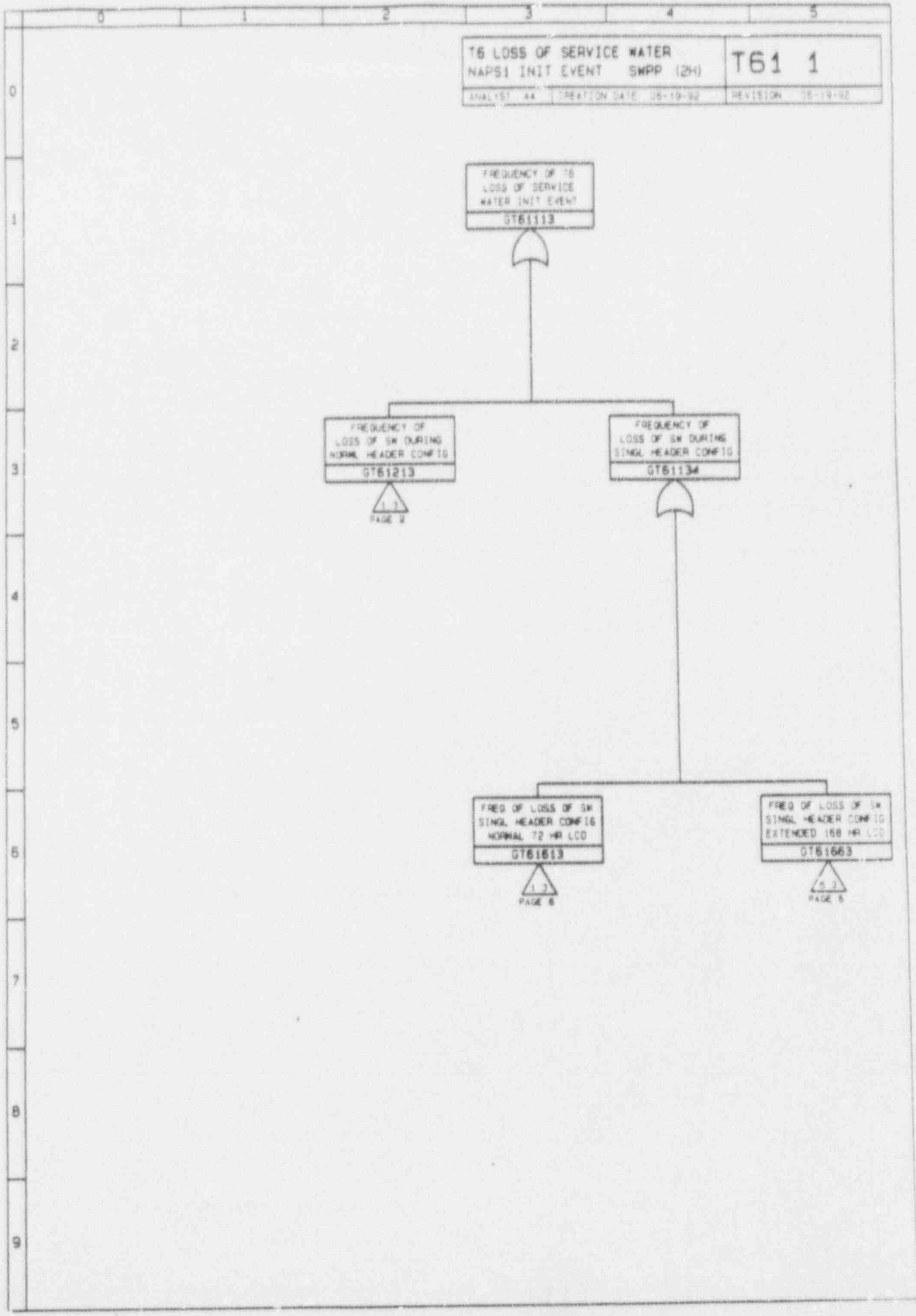
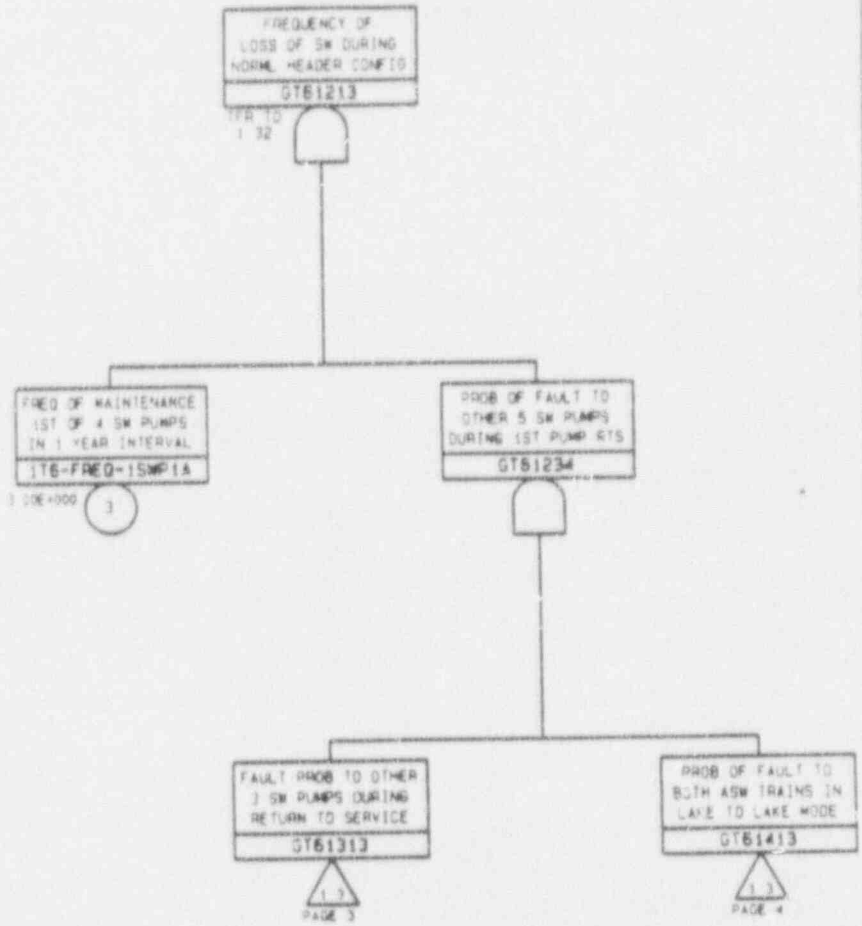
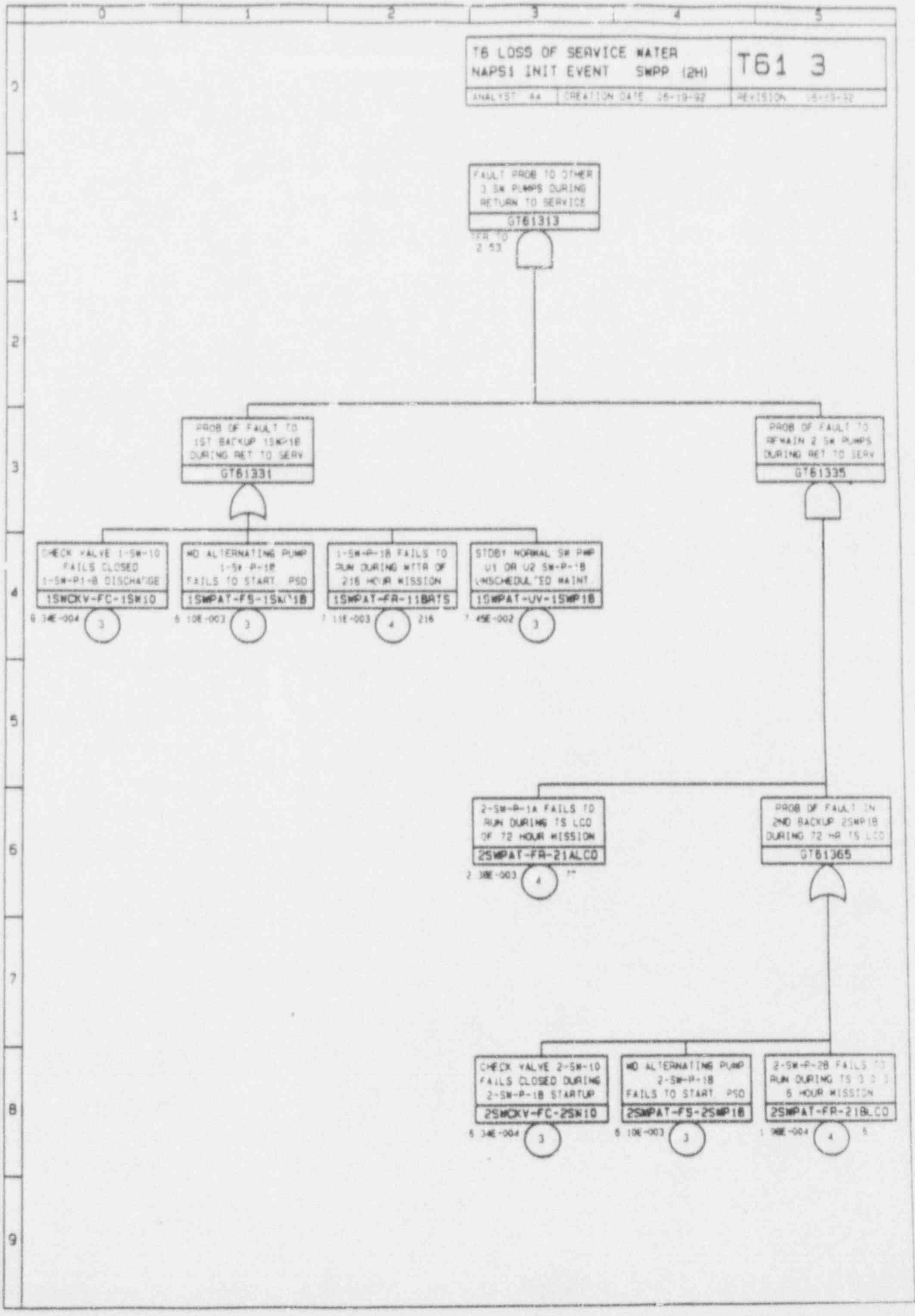


Figure B-3 Frequency of Loss of SW Due to Damage to Heater

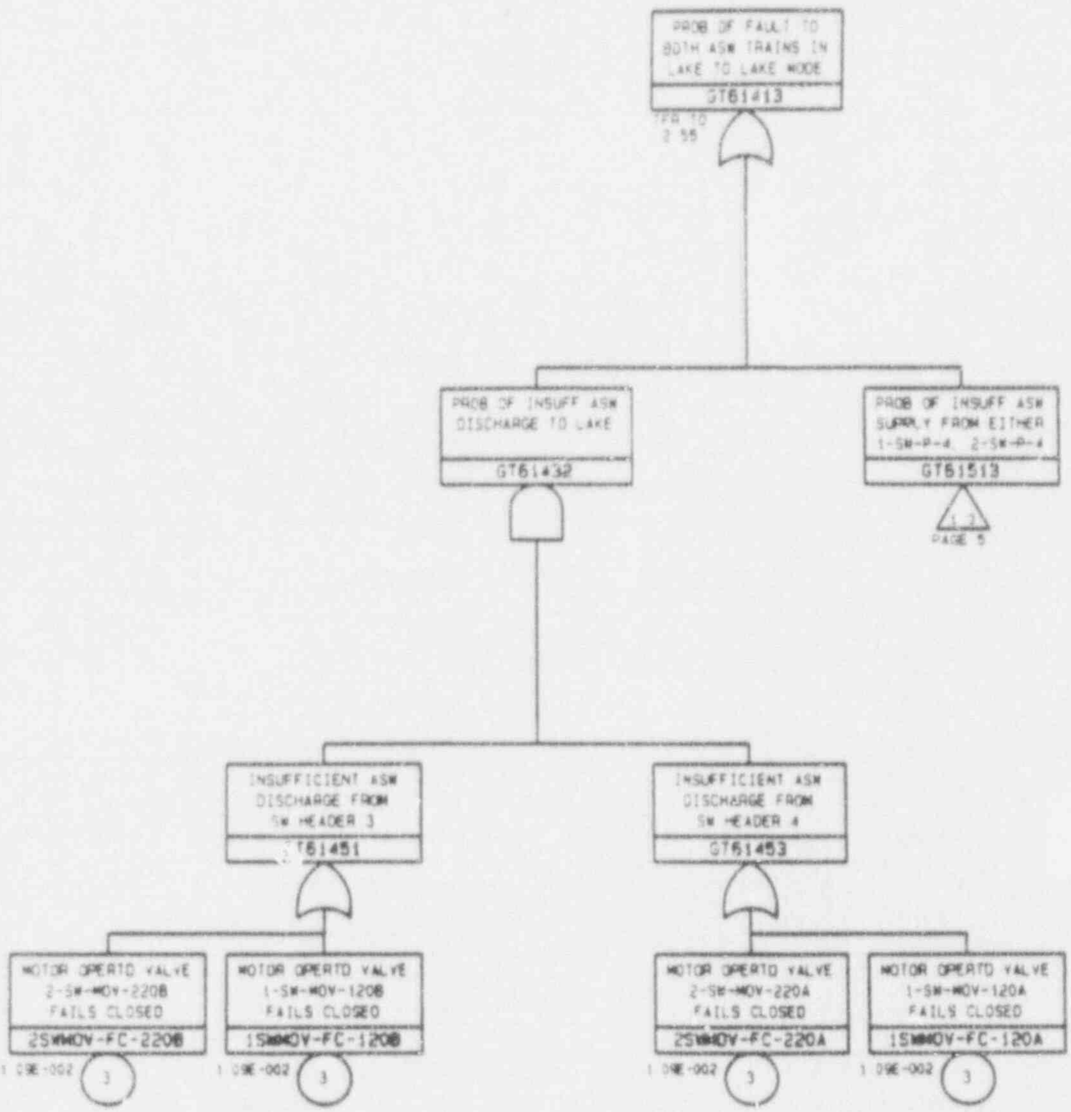
T6 LOSS OF SERVICE WATER NAPS1 INIT EVENT SWPP (2H)	T61 2
ANALYST AA | CREATION DATE 06-19-92	REVISION 06-19-92

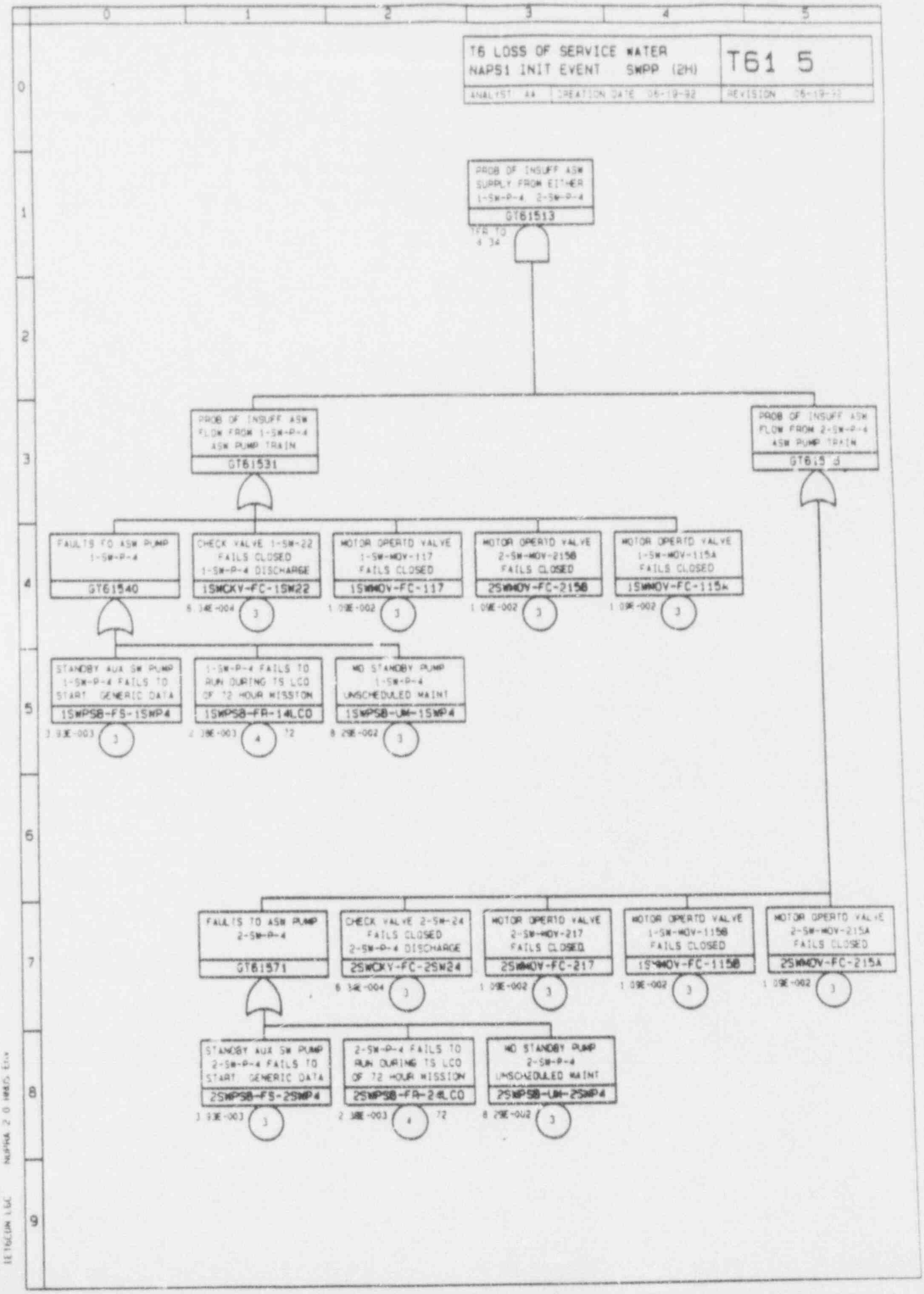




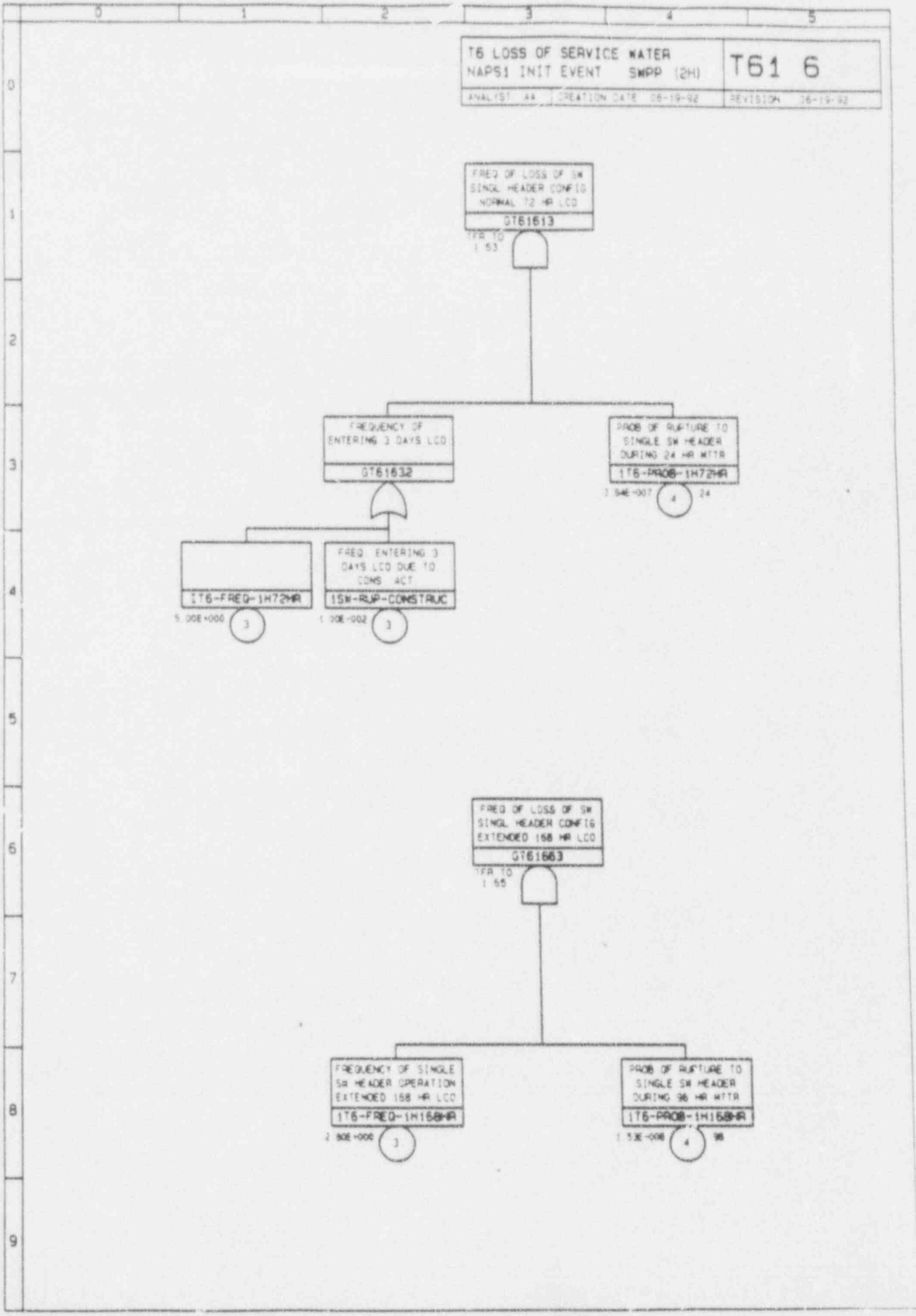
T6 LOSS OF SERVICE WATER
NAPS1 INIT EVENT SWPP (2H)
T61 3
ANALYST AA
CREATION DATE 06-19-92
FAULT PROB TO OTHER 3 SW PUMPS DURING RETURN TO SERVICE
GT61313
PROB OF FAULT TO 1ST BACKUP 1SWP1B DURING RET TO SERV
GT61331
PROB OF FAULT TO REMAIN 2 SW PUMPS DURING RET TO SERV
GT61335
CHECK VALVE 1-SW-10 FAILS CLOSED 1-SW-P1-B DISCHARGE
1SWCKV-FC-1SW10
MD ALTERNATING PUMP 1-SW-P-1B FAILS TO START, PSD
1-SW-P-1B FAILS TO RUN DURING MTTR OF 216 HOUR MISSION
1SWPAT-FR-11BRTS
STDBY NORMAL SW PMP U1 OR U2 SW-P-1B UNSCHEDULED MAINT.
1SWPAT-UV-1SWP1B
2-SW-P-1A FAILS TO RUN DURING TS LCO OF 72 HOUR MISSION
2SWPAT-FR-21ALCO
PROB OF FAULT IN 2ND BACKUP 2SWP1B DURING 72 HR TS LCO
GT61365
CHECK VALVE 2-SW-10 FAILS CLOSED DURING 2-SW-P-1B STARTUP
2SWCKV-FC-2SW10
MD ALTERNATING PUMP 2-SW-P-1B FAILS TO START, PSD
2SWPAT-FS-2SWP1B
2SWPAT-FR-21BLCO

T6 LOSS OF SERVICE WATER NAPS1 INIT EVENT SWPP (2H)	T61 4
ANALYST AA | CREATION DATE 06-19-92	REVISION 06-19-92





T6 LOSS OF SERVICE WATER
NAPS1 INIT EVENT SWPP (2H)
T61 5
ANALYST AA
CREATION DATE 06-19-92
REVISION 06-19-92
PROB OF INSUFF ASW SUPPLY FROM EITHER 1-SW-P-4 2-SW-P-4
GT61513
TFR TO 4 34
PROB OF INSUFF ASW FLOW FROM 1-SW-P-4 ASW PUMP TRAIN
GT61531
PROB OF INSUFF ASW FLOW FROM 2-SW-P-4 ASW PUMP TRAIN
FAULTS TO ASW PUMP 1-SW-P-4
GT61540
CHECK VALVE 1-SW-22 FAILS CLOSED 1-SW-P-4 DISCHARGE
1SWCKV-FC-1SW22
6.34E-004
MOTOR OPERTD VALVE 1-SW-MOV-117 FAILS CLOSED
1SWMOV-FC-117
1.09E-002
MOTOR OPERTD VALVE 2-SW-MOV-215B FAILS CLOSED
2SWMOV-FC-215B
1.09E-002
MOTOR OPERTD VALVE 1-SW-MOV-115A FAILS CLOSED
1SWMOV-FC-115A
1.09E-002
STANDBY AUX SW PUMP 1-SW-P-4 FAILS TO START GENERIC DATA
1SWPSB-FS-1SWP4
3.93E-003
1-SW-P-4 FAILS TO RUN DURING TS LCO OF 72 HOUR MISSION
1SWPSB-FR-14LCO
2.38E-003
72
MD STANDBY PUMP 1-SW-P-4 UNSCHEDULED MAINT
1SWPSB-UM-1SWP4
8.29E-002
FAULTS TO ASW PUMP 2-SW-P-4
GT61571
CHECK VALVE 2-SW-24 FAILS CLOSED 2-SW-P-4 DISCHARGE
2SWCKV-FC-2SW24
6.34E-004
MOTOR OPERTD VALVE 2-SW-MOV-217 FAILS CLOSED
2SWMOV-FC-217
1.09E-002
MOTOR OPERTD VALVE 1-SW-MOV-115B FAILS CLOSED
1SWMOV-FC-115B
1.09E-002
MOTOR OPERTD VALVE 2-SW-MOV-215A FAILS CLOSED
2SWMOV-FC-215A
1.09E-002
STANDBY AUX SW PUMP 2-SW-P-4 FAILS TO START GENERIC DATA
2SWPSB-FS-2SWP4
3.93E-003
2-SW-P-4 FAILS TO RUN DURING TS LCO OF 72 HOUR MISSION
2SWPSB-FR-24LCO
2.38E-003
72
MD STANDBY PUMP 2-SW-P-4 UNSCHEDULED MAINT
2SWPSB-UM-2SWP4
8.29E-002



T6 LOSS OF SERVICE WATER
NAPS1 INIT EVENT SWPP (2H)
T61 6
ANALYST AA
CREATION DATE 08-19-92
REVISION 08-19-92
FREQ OF LOSS OF SW SINGL HEADER CONFIG NORMAL 72 HR LCO
GT61613
TFR TO 1 53
FREQUENCY OF ENTERING 3 DAYS LCO
GT61632
PROB OF RUPTURE TO SINGLE SW HEADER DURING 24 HR MTTR
1T6-PROB-1H72HR
3 94E-007
4
24
1T6-FREQ-1H72HR
5 00E+000
3
FREQ ENTERING 3 DAYS LCO DUE TO CONS ACT
1SW-RUP-CONSTRUC
1 00E-002
3
FREQ OF LOSS OF SW SINGL HEADER CONFIG EXTENDED 168 HR LCO
GT61663
TFR TO 1 55
FREQUENCY OF SINGLE SW HEADER OPERATION EXTENDED 168 HR LCO
1T6-FREQ-1H168HR
2 80E+000
3
PROB OF RUPTURE TO SINGLE SW HEADER DURING 96 HR MTTR
1T6-PROB-1H168HR
1 53E-006
4
96

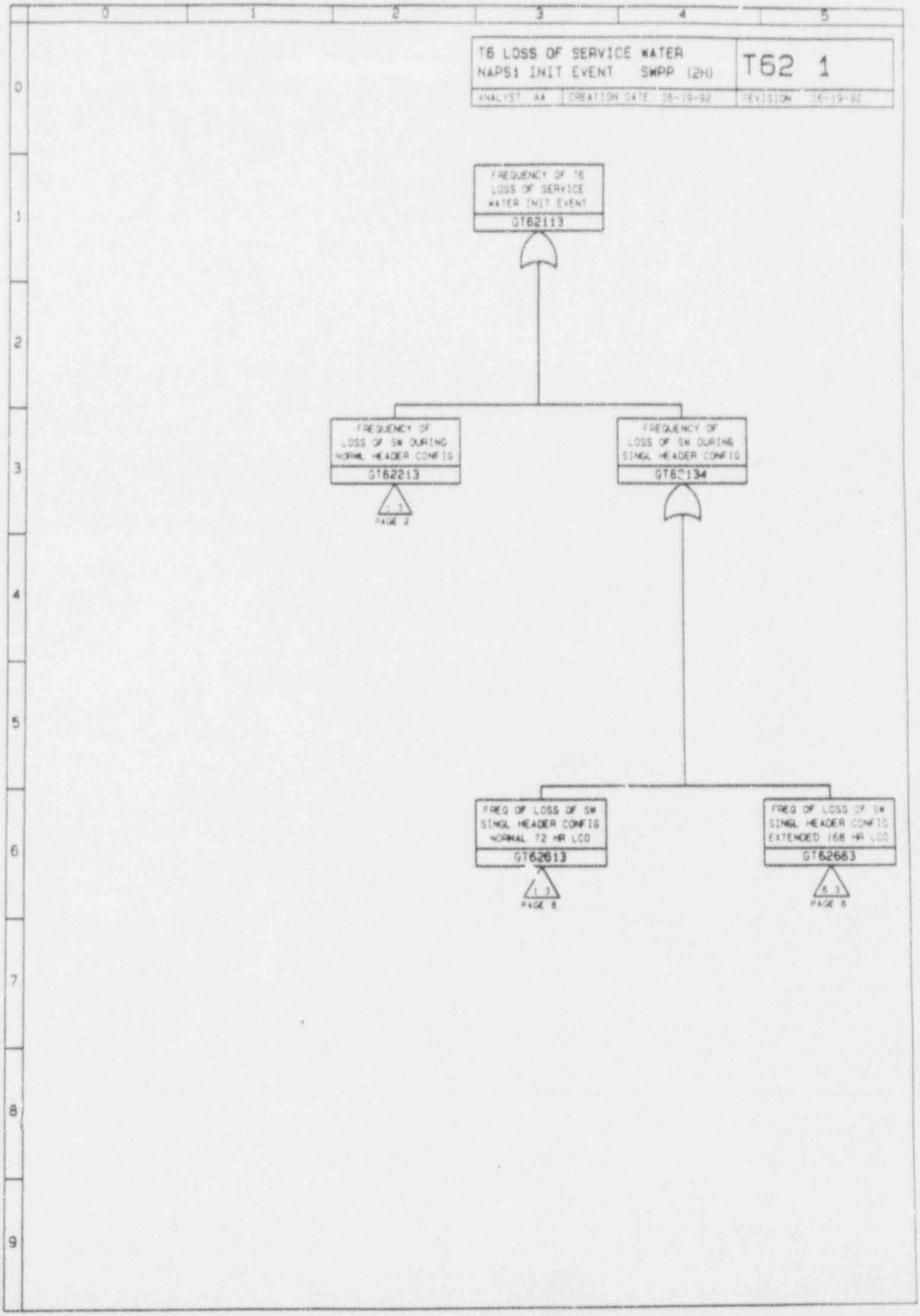
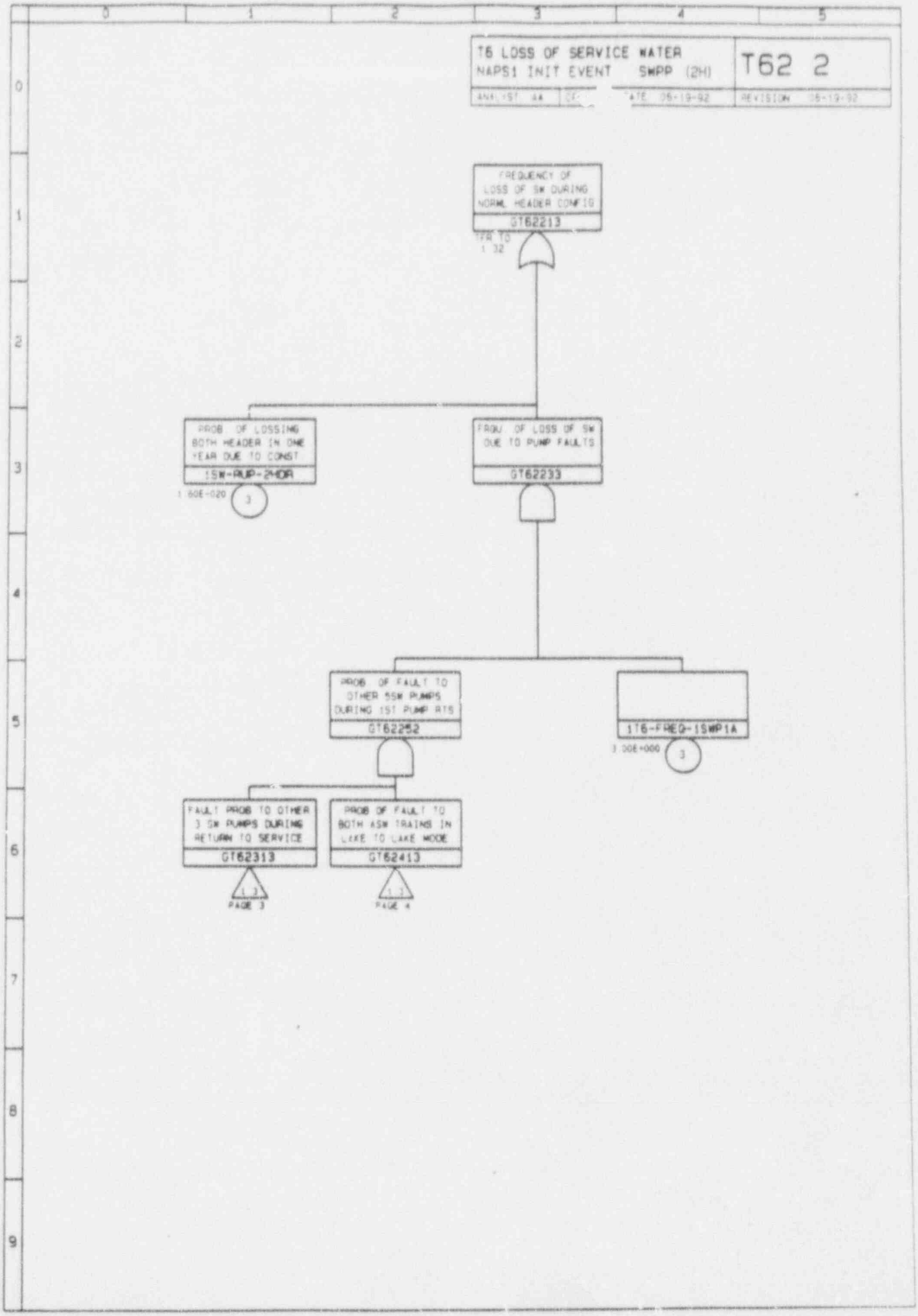
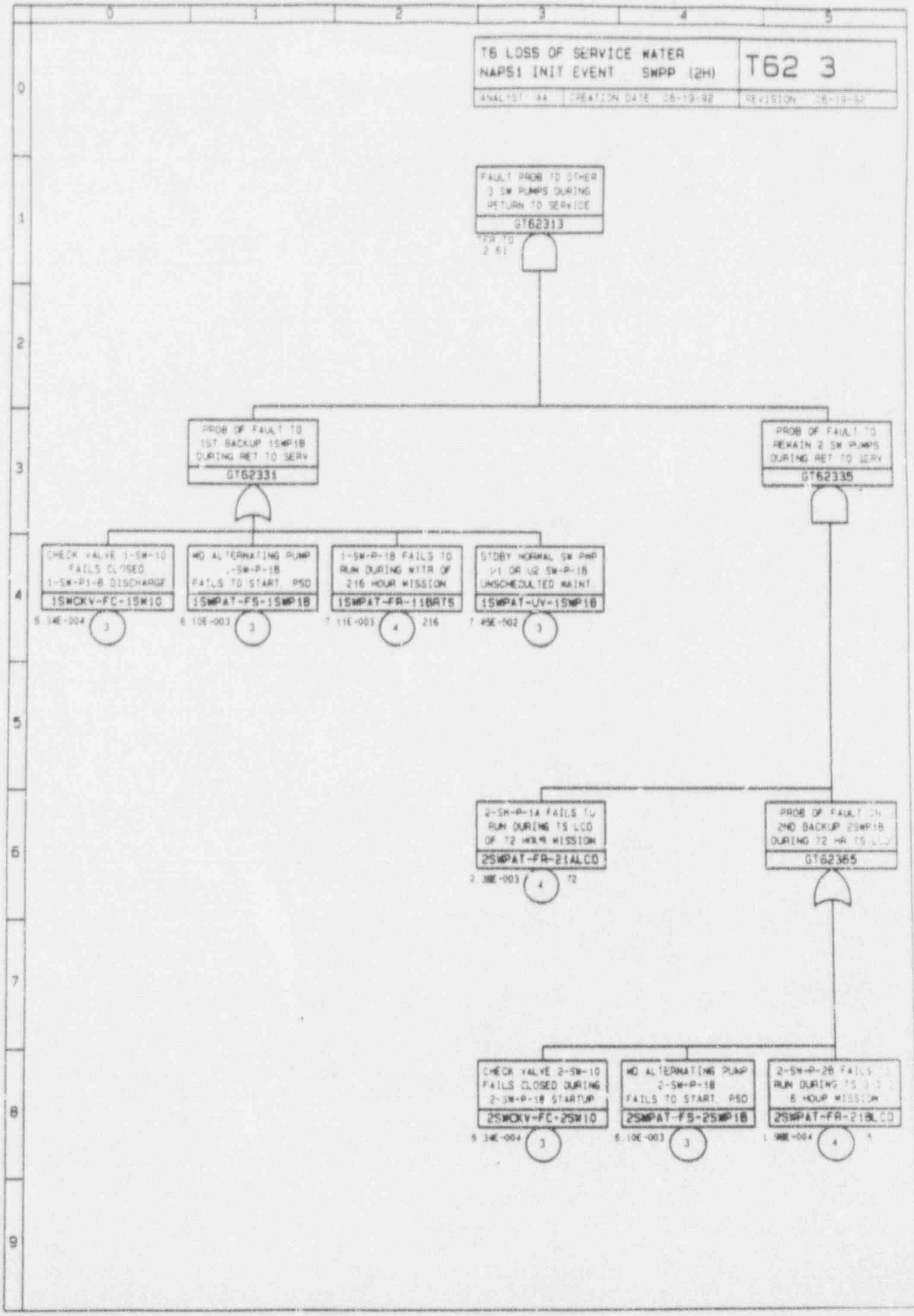


Figure B-4 Frequency of Loss of SW Due to Damage to Both Headers

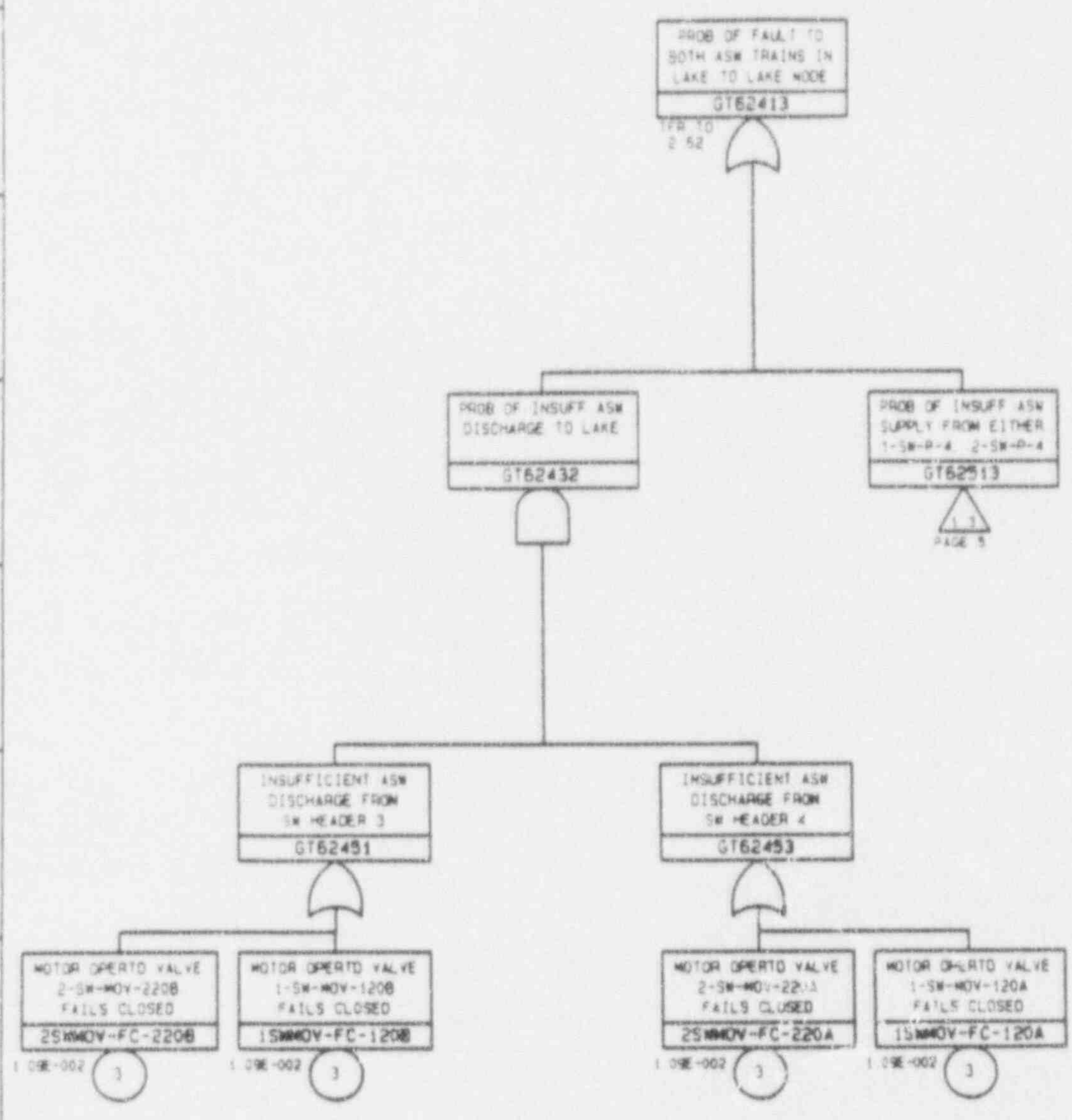


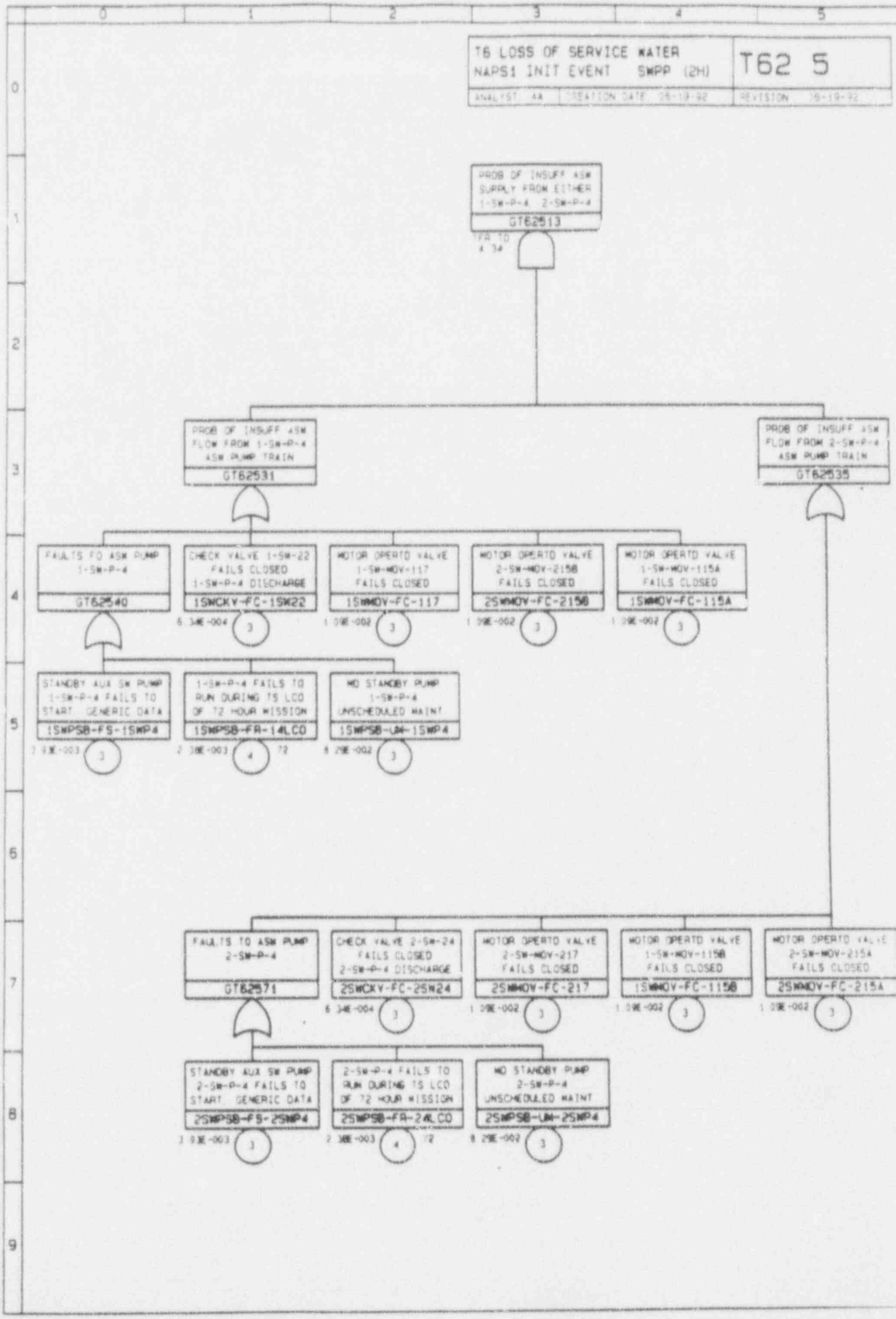
0
1
2
3
4
5
T6 LOSS OF SERVICE WATER
NAPS1 INIT EVENT SWPP (2H)
T62 2
REVISION 05-19-92
FREQUENCY OF
LOSS OF SW DURING
NORML HEADER CONFIG
GT62213
PROB. OF LOSSING
BOTH HEADER IN ONE
YEAR DUE TO CONST
1SW-RUP-2HDR
FRQU. OF LOSS OF SW
DUE TO PUMP FAULTS
GT62233
PROB. OF FAULT TO
OTHER 5SW PUMPS
DURING 1ST PUMP RTS
GT62252
1T6-FREQ-1SWP1A
FAULT PROB TO OTHER
3 SW PUMPS DURING
RETURN TO SERVICE
GT62313
PROB OF FAULT TO
BOTH ASW TRAINS IN
LAKE TO LAKE MODE
GT62413
PAGE 3
PAGE 4
6
7
8
9

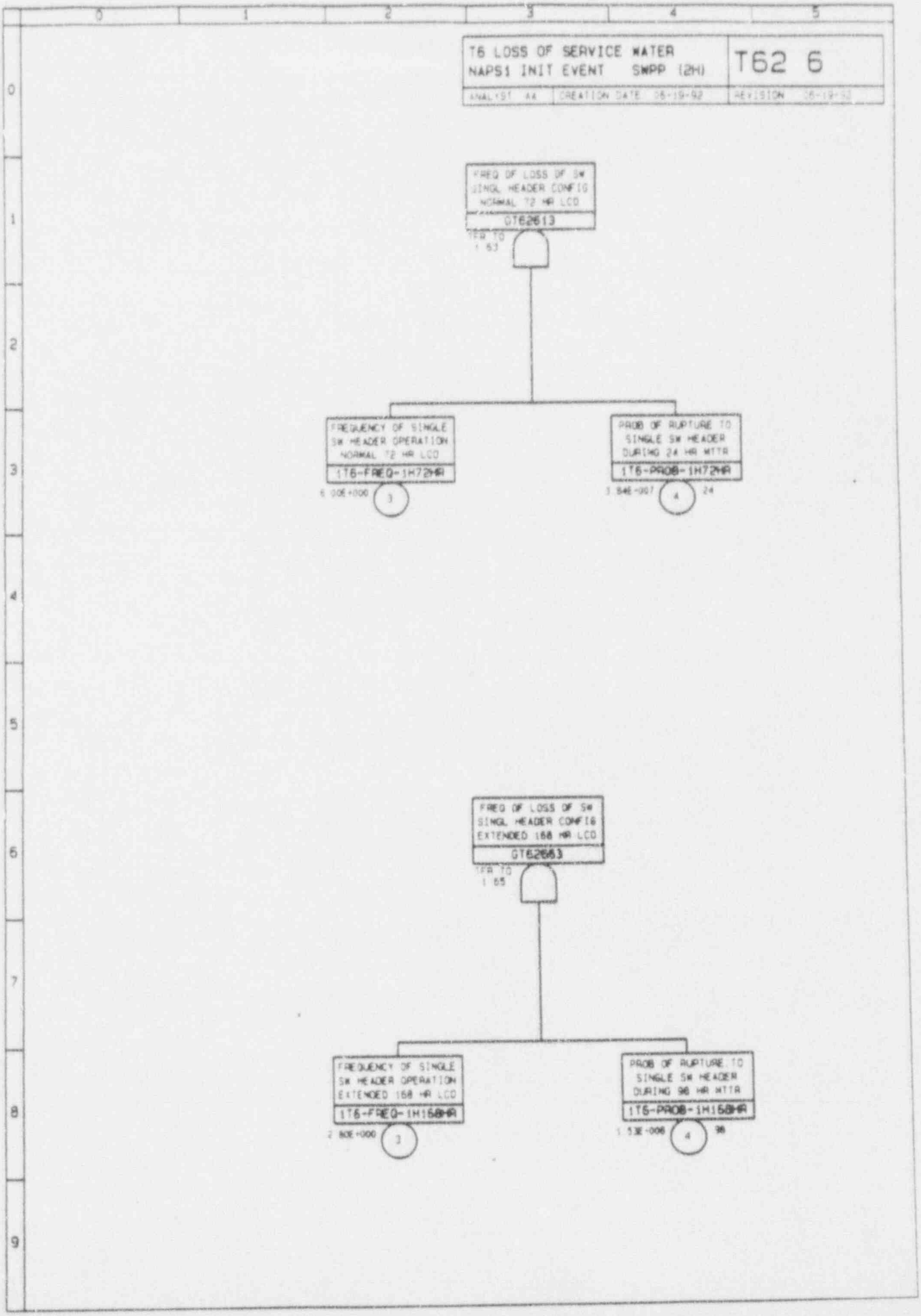


T6 LOSS OF SERVICE WATER
NAPS1 INIT EVENT SWPP (2H)
T62 3
ANALYST: AA
CREATION DATE 06-19-92
REVISION 06-19-92
FAULT PROB TO OTHER 3 SW PUMPS DURING RETURN TO SERVICE
GT62313
PROB OF FAULT TO 1ST BACKUP 1SWP1B DURING RET TO SERV
GT62331
PROB OF FAULT TO REMAIN 2 SW PUMPS DURING RET TO SERV
GT62335
CHECK VALVE 1-SW-10 FAILS CLOSED 1-SW-P1-B DISCHARGE
1SWCKV-FC-1SW10
MD ALTERNATING PUMP 1-SW-P-1B FAILS TO START, PSD
1SWPAT-FS-1SWP1B
1-SW-P-1B FAILS TO RUN DURING MTTR OF 216 HOUR MISSION
1SWPAT-FR-11BRTS
STDBY NORMAL SW PMP U1 OR U2 SW-P-1B UNSCHEDULTED MAINT
1SWPAT-UV-1SWP1B
2-SW-P-1A FAILS TO RUN DURING TS LCO OF 72 HOUR MISSION
2SWPAT-FR-21ALCO
PROB OF FAULT ON 2ND BACKUP 2SWP1B DURING 72 HR TS LCO
GT62365
CHECK VALVE 2-SW-10 FAILS CLOSED DURING 2-SW-P-1B STARTUP
2SWCKV-FC-2SW10
MD ALTERNATING PUMP 2-SW-P-1B FAILS TO START, PSD
2SWPAT-FS-2SWP1B
2-SW-P-2B FAILS TO RUN DURING TS
6 HOUR MISSION
2SWPAT-FR-21BLCO

T5 LOSS OF SERVICE WATER NAPS1 INIT EVENT SWPP (2H)	T62 4
ANALYST: AA / CREATION DATE: 05-19-92	REVISION: 05-19-92




T6 LOSS OF SERVICE WATER
NAPS1 INIT EVENT SWPP (2H)
T62 5
ANALYST: AA
CREATION DATE: 26-10-92
REVISION: 26-10-92
PROB OF INSUFF ASW SUPPLY FROM EITHER 1-SW-P-4, 2-SW-P-4
GT62513
PROB OF INSUFF ASW FLOW FROM 1-SW-P-4 ASW PUMP TRAIN
GT62531
PROB OF INSUFF ASW FLOW FROM 2-SW-P-4 ASW PUMP TRAIN
GT62535
FAULTS TO ASW PUMP 1-SW-P-4
GT62540
CHECK VALVE 1-SW-22 FAILS CLOSED 1-SW-P-4 DISCHARGE
1SWCKV-FC-1SW22
MOTOR OPERTD VALVE 1-SW-MOV-117 FAILS CLOSED
1SWMOV-FC-117
MOTOR OPERTD VALVE 2-SW-MOV-215B FAILS CLOSED
2SWMOV-FC-215B
MOTOR OPERTD VALVE 1-SW-MOV-115A FAILS CLOSED
1SWMOV-FC-115A
STANDBY AUX SW PUMP 1-SW-P-4 FAILS TO START. GENERIC DATA
1SWPSB-FS-1SWP4
1-SW-P-4 FAILS TO RUN DURING TS LCO OF 72 HOUR MISSION
1SWPSB-FR-14LCO
MO STANDBY PUMP 1-SW-P-4 UNSCHEDULED MAINT
1SWPSB-UM-1SWP4
FAULTS TO ASW PUMP 2-SW-P-4
GT62571
CHECK VALVE 2-SW-24 FAILS CLOSED 2-SW-P-4 DISCHARGE
2SWCKV-FC-2SW24
MOTOR OPERTD VALVE 2-SW-MOV-217 FAILS CLOSED
2SWMOV-FC-217
MOTOR OPERTD VALVE 1-SW-MOV-115B FAILS CLOSED
1SWMOV-FC-115B
MOTOR OPERTD VALVE 2-SW-MOV-215A FAILS CLOSED
2SWMOV-FC-215A
STANDBY AUX SW PUMP 2-SW-P-4 FAILS TO START. GENERIC DATA
2SWPSB-FS-2SWP4
2-SW-P-4 FAILS TO RUN DURING TS LCO OF 72 HOUR MISSION
2SWPSB-FR-24LCO
MO STANDBY PUMP 2-SW-P-4 UNSCHEDULED MAINT
2SWPSB-UM-2SWP4


T6 LOSS OF SERVICE WATER
NAPS1 INIT EVENT SWPP (2H)
T62 6
ANALYST AA
CREATION DATE 06-19-92
REVISION 06-19-92
FREQ OF LOSS OF SW SINGL HEADER CONFIG NORMAL 72 HR LCO
GT62613
TFR TO 1 63
FREQUENCY OF SINGLE SW HEADER OPERATION NORMAL 72 HR LCO
1T6-FREQ-1H72HR
6.00E+000
3
PROB OF RUPTURE TO SINGLE SW HEADER DURING 24 HR MTTR
1T6-PROB-1H72HR
3.84E-007
4
24
FREQ OF LOSS OF SW SINGL HEADER CONFIG EXTENDED 168 HR LCO
GT62663
TFR TO 1 65
FREQUENCY OF SINGLE SW HEADER OPERATION EXTENDED 168 HR LCO
1T6-FREQ-1H168HR
2.80E+000
3
PROB OF RUPTURE TO SINGLE SW HEADER DURING 96 HR MTTR
1T6-PROB-1H168HR
1.53E-006
4
96

APPENDIX C

Appendix C

C.1 General Description of the Service Water System

This section discusses the Service Water (SW) System and provides a general description of the system operation, flow paths, and interrelationships with other plant systems. The contents of this section are copied from the Service Water System Training Manual, Module NCRODP-13, June 1992. A simplified SW system diagram is presented in Figure C-1.

The Service Water System is common to both reactor units and is designed for the simultaneous operation of various subsystems and components of both units. The purpose of the SW System is to provide long term cooling after a loss of coolant accident (LOCA) and to supply cooling water to the following safety-related components during normal plant operations:

1. component cooling (CC) heat exchangers;

2. recirculation spray (RS) heat exchangers (available, but not normally flowing);

3. control room air conditioning condensers;

4. charging pump seal coolers, gear reducers, lube oil coolers; and

5. instrument air compressors.

The SW System also serves as a backup source of water to the:

1. Auxiliary Feedwater system.

2. spent fuel pit coolers,

3. containment air recirculation coolers, and

The sources of cooling water for the SW system are the SW reservoir and Lake Anna. These two independent sources of water form the ultimate heat sink for the North Anna Power Station.

Flow Paths

The SW System has two modes of operation: reservoir-to-reservoir and lake-to-lake. It is normally operated in the reservoir-to-reservoir mode which uses the SW reservoir as the ultimate heat sink. The SW reservoir is a large pond with sufficient supply of treated water to provide cooling for four operating units with one of the four units suffering from loss of coolant accident (LOCA). There are two spray headers in the reservoir that spray returning SW into the air to assist in dissipating the heat acquired while cooling the various plant components. Each spray header consists of two pairs (four total) of individual controllable spray arrays. The spray arrays can be bypassed by two spray bypass lines (one per header) leading directly to the reservoir.

There are four SW pumps, of which one pump per unit is normally in operation. The pumps draw SW from the reservoir through a set of traveling screens that filter out debris. The SW pumps provide the motive force for the flow of the SW through the various components cooled by the SW System.

The SW System supplies cooling water through the plant with two supply headers. Two return headers collect the SW from the cooled components and return the water to the reservoir. At the reservoir, the return headers divide the returning SW among the two spray headers or spray bypass lines. Radiation monitors are used to ensure that no radioactive contamination has leaked into the returning SW.

In the lake-to-lake mode of operation, two auxiliary SW pumps draw water directly from Lake Anna through the Circulating Water (CW) System traveling screens. The lake-to-lake mode is used as a backup and during SW System maintenance. The auxiliary SW pumps discharge the

SW to the same supply headers as the SW pumps used in the reservoir-to-reservoir mode. The return headers have an auxiliary return header that directs the return SW to the lake. The auxiliary return header is also monitored for radioactivity by a radiation monitor. Two of the CW screen wash pumps serve as makeup pumps for the SW System and can add lake water to the SW reservoir. The auxiliary SW pumps can also be used to provide makeup water to the SW reservoir.

Subsystems

Screen wash subsystem. The SW System has its own screen wash subsystem that uses two screen wash pumps and four traveling screens. The screen wash subsystem is in the SW Pump House. The traveling screens filter the incoming reservoir water prior to its entering the SW pumps. When sufficient debris is collected on the screens (or once daily), the screens rotate and are cleaned by spray water from the two screen wash pumps. The screen wash pumps use SW from the reservoir. The debris is collected in a trash basket, and the water is returned to the reservoir.

Chemical Addition Subsystem. The Chemical Addition Subsystem purpose is to treat SW System water so as to minimize SW System component and piping corrosion. The subsystem consists of a flow loop which originates at one SW Supply Header and returns to both SW Supply Headers. Chemical treatment equipment in the Service Water Chemical Treatment House stores, controls and injects chemicals into the Chemical Addition Subsystem flow loop. Chemicals injected into the Service Water System Supply Headers via this flow loop are mixed by main Service Water System Header Flow, and Distributed to all parts of the Service Water System.

Air subsystem. The SW air subsystem consists of two air compressors. The air subsystem is in the SW Pump House. The air compressor provides the necessary air to control and monitor the operation of the screen wash subsystem. Air from the SW air subsystem is also used to measure the reservoir level for indication and alarm in the Main Control Room (MCR).

Sump subsystems. The SW sump subsystems remove any leakage and runoff water from the SW Pump House, SW Valve House and SW Tie-In Vault. Drainage from various components collects in the sumps in the lower levels of the structures. The sump pumps periodically return the collected water from the SW Pump House and the SW Valve House to the reservoir. Drainage from the SW Tie-In Vault is discharged to grade outside the Vault.

System Interfaces

Circulating Water (CW) System. The CW System provides filtered lake water to the suction of the auxiliary SW pumps and the makeup pumps. The auxiliary SW return header directs returning water into the Unit 2 discharge tunnel for ultimate return to the lake.

Instrument Air System. Service Water flows through an intermediate cooling loop (part of the IA system) for both instrument air compressors in the Auxiliary Building. IA Compressor and aftercooler temperature control is a function of the IA system.

Feedwater System. The SW System provides a backup source of water to the auxiliary feedwater pumps. The auxiliary feedwater pumps provide feedwater to the steam generators on a loss of normal feedwater capability. SW is the last source of water to be used to supply the auxiliary feedwater pumps because of the chemical contamination that would result in the steam generators.

Chemical and Volume Control System (CVCS). The SW System provides cooling water to the charging pumps in the CVCS. Cooling water is provided to the seal coolers, gear reducers, and lube oil coolers.

Radiation Monitoring System. The Radiation Monitoring System provides a number of radiation monitors that are used to detect possible radioactive leakage into the SW System.

Primary Ventilation System. The SW System provides cooling water to the MCR air conditioner condensers. The SW System also provides a backup source of water to the containment air recirculation coolers that are normally supplied with water from the Chilled Water System.

Spent Fuel Pit System. The SW System provides a backup source of water to cool the spent fuel pit coolers. The coolers are normally cooled by CC, but they can be cooled by SW if CC is not available.

Component Cooling System. SW is provided to cool the CC heat exchangers. Most the components for which SW is the backup source of water are normally cooled by the CC System.

Recirculation Spray System. The RS heat exchangers are cooled by SW on receipt of a containment depressurization actuation (CDA) signal. The RS System is used to depressurize containment during a LOCA or main steam line break in Containment and to provide long term containment cooling during a LOCA.

Reactor Protection System (RPS). The RPS generates the CDA and safety injection (SI) signals that alter the SW lineup. The CDA signal initiates SW flow through the RS heat exchangers and isolates SW flow through the CC heat exchangers. SW, which is not normally supplied to the containment air recirculation coolers, is also isolated on receipt of a CDA signal. The SI signals starts the SW pumps and ensures that all of the SW reservoir spray header isolation valves are open and the spray bypass valves are closed for maximum SW cooling capability.

C.2 Identification of Computer Code Used and Computer Employed

The NUPRA computer code was used for fault tree input and solution. NUPRA was written by HALLIBURTON NUS Environmental Corporation (formerly NUS Corporation) and is a

personal computer (PC) based code. The solution of fault trees by NUPRA has been verified by hand calculations and also by comparison of results with the mainframe based SETS computer code (an industry and NRC accepted code for fault tree solution).

The version of NUPRA used is Version 2.0.

C.3 Fault Tree Development

The method of fault tree development creates a systematic format for gathering and evaluating system data. The fault tree itself is the logical combination of this information to generate the system unavailability. The SW system fault tree model is shown in Figure C-2 and major topics of the fault tree development are briefly discussed below. Detailed information on these topics are provided in the following subsections.

- Determination of System Success Criteria. The success criteria for a system form the basis for the top event for each fault tree.

- Development of Simplified Schematic. The simplified schematic models the system as represented in the analysis, and is a critical element of the systems analysis. It identifies those components included in the model, defining their boundaries. It identifies interfaces with other systems and establishes the system limits for analysis as well as identifying areas for interaction between the model and other fault trees.

- Determination of Support System Interfaces. Through the generation of a Dependency Matrix, the interfaces with support systems such as electric power, control power, instrument air, cooling water, etc. are identified.

- Generation of Test and Maintenance Matrices. Surveillance testing and preventative maintenance performed at power can be a noteworthy source of

component unavailability. The matrices identify such procedures, and provide information needed to evaluate their impact upon component unavailability.

- Operating Experience Review. Often, plant operation will identify unforeseen component failure modes or unexpected operating evolutions. Generally these items are not addressed within design documentation, so that a review of plant operating experience is needed to identify and incorporate these failures and evolutions where they impact unavailability.

- Identification of Differences between Units 1 and 2. For North Anna, there are few intentional differences between the units, nevertheless, a concerted effort to evaluate dependencies, procedures, etc., is needed to verify similarity or to identify differences so that a unique Unit 2 model can be generated.

C.3.1 System Success Criteria

The system success criteria form the basis for the top event of each fault tree. The following Service Water system success criterion has been established:

> Provide sufficient water through SW system header "A" to provide adequate cooling for the RS heat exchangers, control room air conditioning condensers, charging pump seal coolers, p[illegible] educers, and lube oil coolers for a 24-hour mission time. In order to meet these functional requirements, one pump and one supply header are required for one unit. Operation of the second unit requires only one additional pump.

C.3.2 Development of Simplified Schematic

The SW System simplified drawing for the SW fault tree is provided in Figure C-1. This simplified schematic was used as the basis for fault tree development for both Unit 1 and Unit

2 since the SW System is shared between the two units. This schematic was developed by taking Figure 1_-2 from training manual #13 and detailing it per the following drawings:

Drawing	Revision
11715-FM-078A Sh. 1	35
11715-FM-078A Sh. 3	26
11715-FM-078A Sh. 4	41
11715-FM-078B Sh. 1	18
11715-FM-078C Sh. 2	31
11715-FM-078G Sh. 1	11
12050-FM-077A Sh. 1	16
12050-FM-077A Sh. 2	13

C.3.3 Support System Interfaces

The SW fault tree support system interfaces are identified with Dependency Matrices. The dependency matrices for the SW System are obtained from the IPE system notebook. All SW support systems are modelled based on these dependency matrices.

Test and Maintenance Matrices

The Test and Maintenance matrices serve two functions. First, they summarize a review of North Anna Periodic Test and Preventive Maintenance procedures to identify scheduled PT's or PM's at power. These events can lead to component unavailability and can be modeled in the fault trees with the TM (Scheduled Test and Maintenance) fault. Second, the Test and Maintenance matrices provide input to the Data Base task for quantifying TM faults identified by the System Analysts.

The Test and Maintenance matrices for the Service Water System components is provided in the IPE system notebook. From these matrices, it can be seen that TM faults are not required for any of the components because none of the Periodic Testing procedures require any components

of the SW trains to be made inoperable durin power operations. No Preventative Maintenance procedures were identified for the SW components. Unscheduled maintenance will be included in the fault tree based on historical experience at North Anna. Procedures performed only during refueling or cold shutdown were automatically excluded from consideration.

Operating Experience Review

North Anna Unit 1 and Unit 2 Licensee Events Reports (LERs) were reviewed to identify operating experience that may be of value to system modeling. The review was aimed towards identifying Common Cause Faults (CCFs) or unusual operating modes that could affect system reliability. The LER review covered the last five years of operation. None of the LERs reviewed provided additional faults that needed to be explicitly included in the fault tree.

Fault Tree Modelling Assumptions

This section describes the assumptions used to model the SW fault trees.

1. For valves that are passive (normally open) components in standby, the plugged (PG or PL) failure mode applies. For components that are normally closed (N.C.) plugging is not explicitly modeled, but is assumed to be included in the fail closed (FC) parameter. The origin of this assumption is NUREG/CR-1363. "Data Summaries of LERs of Valves at U S. Commercial Nuclear Power Plants," which describes valve plugging as an event that would stop or limit flow through a normally open valve. Since standby check valves are normally closed, no Type 2 (standby) plugging of check valves (CKV) is assumed.

2. Type 4 plugging failures of normally open manual valves is not modeled. These faults are considered to be of low probability compared to plugging in standby.

3. Common cause failures are generally applied only to standby components. Exceptions to this rule are noted where applicable. Using this assumption, common cause failures

(CCFs) are not applied to a 2 train system where 1 train is running and 1 train is in standby.

4. A 24-hour mission time is assumed for all running components (NUPRA Failure Mode 4). For evaluation of the reliability of the SW system during any 7 day period, the mission time for all pertinent time dependent failures were increased to 7 days.

5. 1A Service Water Pumps (1-SW-P-1A and 2-SW-P-1A) are assumed to be the normally running pumps for the SW System. Pumps 1-SW-P-1B and 2-SW-P-1B are assumed to be in standby. It is also assumed that the SW pumps are alternated every month. Pump 1-SW-P-1A is assumed to be aligned to service water supply header 1(A). Pump 2-SW-P-1A is assumed to be aligned to service water supply header 2(B). Similarly, the auxiliary service water pumps are assumed to be in standby with one pump aligned to each alternate service water header.

6. Per prior assumption, manual valves in running trains do not experience plugging faults.

7. Per prior assumption, manual valves in standby trains are assumed to be subject to plugging faults if they are normally open.

8. Failure Mode 2 events for the standby manual valves on the outlet of the SW standby pumps and the CW pumps assume a 720 hour interval between valve verification. It is assumed that the SW pumps are alternate every month, thus allowing the valves to be checked once a month. The CW pumps are run at irregular time intervals so it is hard to set an exact time interval but a month's time frame should cover at least one traveling screen wash.

9. The general guidelines for the fault tree analysis is that if an active failure mode is postulated for an MOV, there is no reason to include a plugging failure mode also.

10. SW pumps will start automatically on receipt of an SI signal from either unit or a loss of reserve station power provided that all the following conditions are met:

1) SW pump handswitch is in Auto after Start position
2) no motor overload
3) no undervoltage or degraded voltage

It is assumed for the fault tree that these conditions are met.

11. According to the UFSAR, the water stored in the service water reservoir can provide service water for extended periods for four units should the normal makeup pumps be inoperative. Enough water is available to guarantee 30 days of operation for four units without makeup. It was originally planned for North Anna to contain four operating units but only two were built. The reservoir was still designed to provide for four units providing more than sufficient water for the two units and, therefore, loss of service water will not be modeled as a fault for this system.

12. It has been determined, based on operating history, that the traveling screens to the service water pumps could become plugged within a 24-hour period. Therefore, the traveling screens to the SW pumps need to be modeled. The CW traveling screens, used by the Auxiliary SW System, can become plugged with fish. These screens will be modeled as undeveloped events; one for each screen type. A common cause event will also be defined for the SW screenwells and the CW screenwells.

13. The service water air subsystem supplies air for the reservoir level indicator and for the traveling screen differential pressure indicators. Since is has been determined that the level of the reservoir is guaranteed adequate for 30 days, the level indicator will not be considered necessary to be modeled for the Service Water System.

14. The self-cleaning strainers (2-CW-S-3A/B) are apparently cleaned by diverting some of

the screen wash flow past the surface of the strainer through 2-CW-MOV-204A/B. It is assumed that the closure of these valves lead to plugging of the strainers.

15. During the periodic testing for the SW and Auxiliary SW pumps, certain valves are realigned. A restoration fault for these valves was not included in the fault tree because the procedure includes a check-off list that should verify that these valves are restored to their previous position and these valves are also visually inspected monthly to verify that their position is correct.

16. Opening the cross-tie between the two Auxiliary SW pumps was not modeled as a recovery action for the loss of a pump because as part of the success criteria it is necessary to have SW available to both units. Therefore, it was decided that each Auxiliary SW pump would be available as an alternate supply of SW for only one unit.

17. The training manual for the CW system states that;

"Normally the screen wash pumps are secured. The operator monitors screen differential level on a periodic basis and, at an indicated level of 2 to 3 inches of water, manually initiates washing of the individual screen."

Based on this information, the screen wash pumps and traveling screens were modeled to start running when manually started and not through the use of the automatic timer.

18. SW pumps 2-SW-P-1A and 2-SW-P-4 are assumed to be dedicated to Unit 2 and no credit for their availability is taken for Unit 1.

19. Per 1-MOP-49.07, for one supply header operation, 3 SW pumps are aligned to the operable supply header, with alignment of the fourth pump optional. In this analysis it is assumed that all four pumps are aligned to the operable header.

When one header operation, the following additional assumptions have been made:

(1) 3 out of 4 SW pumps and both auxiliary SW pumps are available (i.e., no maintenance is scheduled for 3 out of 4 SW pumps and both auxiliary SW pumps, during the one header operation).

(2) No maintenance activity is schedule for Electrical Emergency Bus 1H, 2H, 1J, and 2J.

(3) No maintenance activities on the DGs associated with the pumps taken credit for to satisfy assumption 1.

SW Induced Change In Core Damage Frequency

The loss of SW System contributes to the plant operational risk under two failure scenarios. The first scenario is the loss of service water system during an accident. That is, after occurrence of an accident inducing plant trip and during the cooldown process, the SW System may fail to provide its intended function. The second scenarios is the loss of SW System during normal operation of the plant, resulting in a plant trip. This analysis will address contribution from both these risk inducing scenarios.

Loss of SW During an Accident (CASE 1)

The North Anna Power Station (NAPS) Individual Plant Examination (IPE) project models several accidents which would necessitate tripping of the plant (Called Initiating Events (IE)). Upon tripping of the plant (i.e., occurrence of an IE), several systems and measures (accident mitigating systems/measures) are taken credit for as being functional to achieve successful safe shutdown of the affected unit. The IPE models also evaluate the probability of failure of these accident mitigating systems/measures. Service water system acts as a support system for several Accident Mitigating Systems (AMS) and its failure will render the AMS ineffective. Thus, any

degradation in the configuration of the SW System that will decrease the reliability of the system, will in turn affect the availability of the AMS. The accident mitigating system/measures which are modeled as being supported by the SW system are shown in Table C-1.

The change in risk, due to the increase in the unreliability of the SW System induced by the one loop operation of the system is given by:

$$\text{Delta } CDF_{SU}(\text{for unit 2 only}) = (CDF_{2H} - CDF_{1H}) * f$$

where

CDF_{SU}	=	Change in CDF induced by the increase in unreliability of the SW System
CDF_{2H}	=	Core Damage Frequency when in Two Header Operation
CDF_{1H}	=	Core Damage Frequency when in One Header Operation
f	=	Fraction of a Year in One Header Operation

The CDF_{2H}, and CDF_{1H}, are evaluated by quantification of the latest IPE model for NAPS core damage frequency.

Loss of SW During Normal Operation (CASE 2)

The NAPS IPE project also evaluates the CDF as a result of loss of service water when no other IE has occurred. SW system supports several normally operating (eg component cooling water system) and standby systems (eg recirculation spray system). Loss of SW is considered to lead to a reactor trip similar to the loss of emergency switchgear room cooling and is designated as T6 initiating event.

The one header operation induced change in CDF can be evaluated by:

i) Evaluating the frequency of the T6 initiating event, based on the historical data (i.e. frequency of T6 as used in the IPE project) .

ii) Evaluating the contribution of the T6 Initiating Event (IE) to CDF with the frequency of T6 as evaluated in step (i), C_{BASE}^{CDF}. This step is carried out by quantification of the T6 IE event tree.

iii) Evaluating the frequency of the T6 initiating event, assuming that the system would be in one header operation for an entire year.

iv) Evaluating the contribution of the T6 initiating event to CDF with the frequency of T6 as evaluated in step (iii), C_{1H}^{CDF} and requantification of the T6 IE event tree.

iv) Evaluating the change in the CDF by subtracting C_{1H}^{CDF} from C_{BASE}^{CDF}.

Mathematically, these steps are presented by:

$$\text{Delta CDF}_{T6} = (C_{2H}^{CDF} - C_{1H}^{CDF})$$

where

CDF_{T6} = Change in CDF induced by the increase in the frequency of T6 initiating event

Service Water Reliability (CASE 3)

In addition to the above failure scenarios, the SW reliability in two (CASE 3A) and one header (CASE 3B) operation modes, for any 7 day mission time, was also evaluated. The purpose of this evaluation was:

1) To identify the most significant contributors to the increase in the unreliability of the SW system during one header operation and recommend mitigating measures

to reduce the unreliability.

C-4 Evaluation of the Impact of the SWPP PRA Recommendations on the Change in CDF

The SWPP PRA identified several modifications which if implemented would reduce the risk associated with the pipe preservation project even further. This section describes the proposed modifications and the methodology used to evaluate their impact.

C-4.1 RECOM. 1- Providing Backup Cooling to the Unit 2 Emergency Switch Gear Room when in One Header Operation.

One of the most important functions of the SW system is to support the ESGR HVAC system. NAPS IPE project has identified that, under the present plant configuration, loss of SW system will render the ESGR HVAC system unavailable, which will have severe adverse effect on the plant accident mitigating capabilities. During normal operation of the plant (2 header operation), due to high reliability of the SW system, the loss of the ESGR HVAC caused by the loss of SW system is not considered as a likely event. In one header operation mode, on the other hand, the probability of the loss of SW system, and consequently the loss of ESGR HVAC system, will increase significantly. However, operation of the SW system in one header configuration is limited and the SWPP PRA study indicates that the impact on the plant operational risk is not significant. Additionally, during one header operation, the Fire Protection System (FPS) is aligned to be used as a back up for the SW system to the HHSI pumps component coolers (AP 12).

However, if ESGR is lost, the HHSI pumps will trip rendering the AP 12 measures ineffective. Thus any operational, procedural, or physical modification of the plant that will reduce the probability of the loss of ESGR (due to excessive heat) in an event of SW failure will reduce the risk even further. Using the Bearing Cooling System (BCS) as a backup for the SW system to the ESGR HVAC chillers is an option which is recommended and its effect has been evaluated in this study.

Using the BCS training module and pertinent drawings a fault tree model for the BCS was developed and the unavailability of the BCS was evaluated. Then, the loss of SW initiating event event tree (as modelled in the NAPS IPE) was modified to account for the recovery of the ESGR cooling and the charging pump coolers (using FPS which its probability of failure was also modelled and quantified). The fault trees for the BCS and FPS are shown in Figure C-3 and C-4 respectively, and the modified event tree is shown in Figure C-5. The contribution of the loss of ESGR cooling to the CDF was then evaluated using the modified event tree. The contribution decrease by factor of 1.7.

C.4.2 RECOM. 2 Providing The Pipe Repair Capability in The Auxiliary Building.

The NAPS IPE identified the pipe rupture in the auxiliary building as the most significant contributor to the loss of SW system when in one header operation. The SWPP PRA further identified that providing the FPS as a backup system for the SW system to the charging (HHSI) pumps' coolers will be less effective, if the SW rupture occurs in the Auxiliary Building, since the ability to discharge the water could be lost in some occasions.

The NAPS IPE has also identified all the SW component which their postulated failure could lead to the loss of SW system. A list these components are shown in Table C-2. As evident from the table the most significant contributors are located in the auxiliary building. Any measure which reduces the probability of these component failing will reduce the loss of SW system initiating event contribution to the CDF. A possible measure is to provide dedicated and trained team of repair personnel with proper instructions, tools and components to repair ruptured components. Since the postulated ruptured components are of 10 and 4 inch diameter this measure is deemed to be feasible. However, credit is taken only for those rupture which are not double ended ruptures. The result of such a measure would be to reduce the initiating event frequency. Table C-3 shows the modified contribution of the SW piping rupture to the T6 initiating event. Using the SW initiating event fault tree the T6 initiating event frequency was re-evaluated and using the IPE T6 initiating event event tree the contribution to CDF was calculated. The contribution of the T6 initiating event, when in one header operation, after the

implementation of the above modification is 1.42E-5 compared to 4.65E-5 which is the contribution of the T6 initiating event frequency, in one header operation, before the modification.

C.4.3 RECOM. 1 and RECOM. 2

The most beneficial measure is to implement both of the modifications described above. The impact of the both modifications was evaluated by taking the T6 initiating event frequency as calculated for RECOM. 2 and re-evaluate the contribution to CDF using tne modified T6 event tree developed for RECOM. 1. The resulting contribution to the CDF was found to be 8.53E-6.

TABLE C-1

Accident Mitigating Systems/Measures Supported by the SW System

SYSTEM	IPE FAULT TREE
1-Component Cooling Water (CCW) System	CC100
2-Chemical Addition System	CH100
3-Feed and Bleed Measure	FB400
4-High Head Safety Injection System	HH100
5-Emergency Switch Gear Room Cooling	HV100
6-Recirculation Spray System	RS100

Table C-2
SW Piping Sections Contributing to T6 IE

Components	Frequency Best
1- 2 36" dia. EJ on the SW Header in the SWPH	6.5E-07
2- 36" dia. Piping up to the Point the Piping Enters the ground	1.6E-08
3- 4" dia. Piping Supply to the Unit 2 Air Cond. Unit up to the Isolation Valve	4.2E-06
4- 4" dia. Manual Isolation Valve for the Unit 2 Air Cond. Unit	6.3E-06
5- One 24" dia. MOV on the Aux. SW Supply to the Normal Supply Header	1.3E-05
6- Piping Section Between the Aux. SW Isolation Valve and the 24" Normal Supply Header	1.7E-06
7- 4" dia. Man. Isolation Valve to the Charging	6.3E-06
8- 4" dia. Piping Downstream of the Manual Isolation Valve for the SW Supply to the Charging Lube Oil Coolers	4.9E-06
9- 4" dia. Man. Isolation Valve on the Return from the Charging Pumps Lube Oil Coolers	2.5E-06
10- 4" dia. Piping Upstream of the Manual Isolation Valve on the Return Header from SW Supply to the Charging Pumps Lube Oil Coolers	2.0E-6
11- 10" dia. Isolation MOV for the Return Header from the SW Supply to the CCW Fuel Pit Coolers	8.3E-05
12- 10" dia. Piping Upstream of the Isol. MOV for the Return Header from the SW Supply to the CCW Fuel Pit Coolers	1.1E-05
13- 24" dia. Isolation MOV on the Return Header to CW Discharge Tunnel	3.5E-06

Table C-2 Continued
SW Piping Sections Contributing to T6 IE

Components	Frequency Best
14- 24" dia. Piping from the Normal Return Header up to the Isolation MOV on the Return Header to CW Discharge Tunnel	3.4E-07
15- 4" dia. Isolation Valve for Return Header from the Unit 1 Air Cond. Unit	6.3E-07
16- 4" dia. Piping Between the Return Isolation Valve for the Unit 1 Air Cond. Unit and the Normal Return Header	1.1E-06

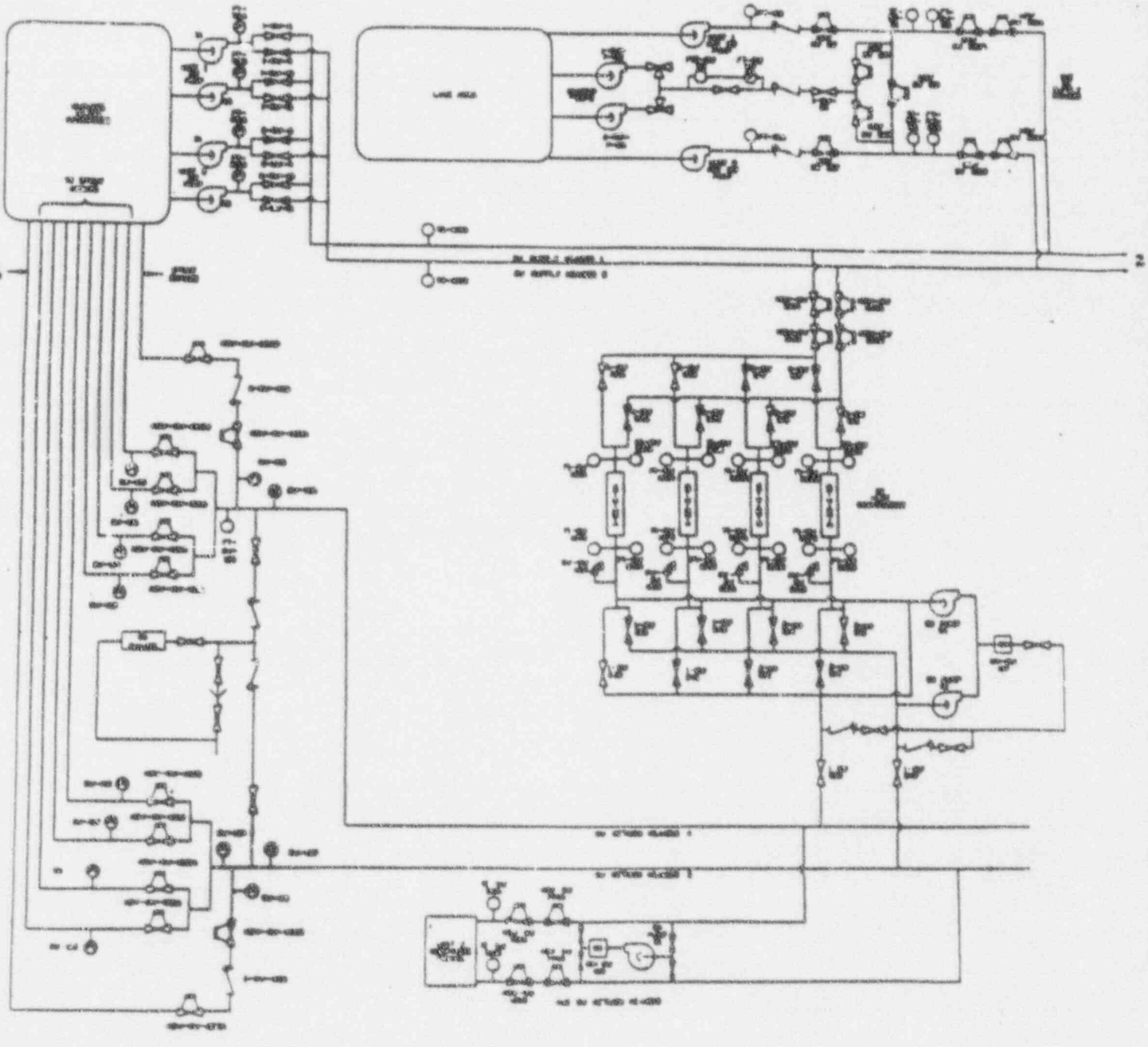
Table C-3
SW Piping Sections Contributing to T6 IE
if Recomn. 2 is Implemented

Components	Frequency Best
1- 2 36" dia. EJ on the SW Header in the SWPH	6.5E-07
2- 36" dia. Piping up to the Point the Piping Enters the Ground	1.6E-08
3- 4" dia. Piping Supply to the Unit 2 Air Cond. Unit up to the Isolation Valve	4.2E-06
4- 4" dia. Manual Isolation Valve for the Unit 2 Air Cond. Unit	6.3E-06
5- one 24" dia. MOV on the Aux. SW Supply to the Normal Supply Header	1.3E-05
6- Piping Section Between the Aux. SW Isolation Valve and the 24" Normal Supply Header	1.7E-06
7- 4" dia. Man. Isolation Valve to the Charging Pumps Lube Oil Coolers	6.3E-07
8- 4" dia. Piping Downstream of the Manual Isolation Valve for the SW Supply to the Charging Lube Oil Coolers	4.9E-07
9- 4" dia. Man. Isolation Valve on the Return from the Charging Pumps Lube Oil Coolers	2.5E-07
10- 4" dia. Piping Upstream of the Manual Isolation Valve on the Return Header from SW Supply to the Charging Pumps Lube Oil Coolers	2.0E-07
11- 10" dia. Isolation MOV for the Return Header from the SW Supply to the CCW Fuel Pit Coolers	8.3E-06
12- 10" dia. Piping Upstream of the Isol. MOV for the Return Header from the SW Supply to the CCW Fuel Pit Coolers	1.1E-6
13- 24" dia. Isolation MOV on the Return Header to CW Discharge Tunnel CW Discharge Tunnel	3.5E-06
14- 24" dia. Piping from the Normal Return Header up to the Isolation MOV on the Return Header to CW Discharge Tunnel	3.4E-07

Table C-3 Continued
SW Piping Sections Contributing to T6 IE
if Recom. 2 is Implemented

Components	Frequency Best
15- 4" dia. Isolation Valve for Return Header from the Unit 1 Air Cond. Unit	6.3E-07
16- 4" dia Piping Between the Return Isolation Valve for the Unit 1 Air Cond. Unit and the Normal Return Header	1.1E-06
Total Rupture Frequency per year	4.2E-05

Figure C-1
Simplified Service Water System Diagram



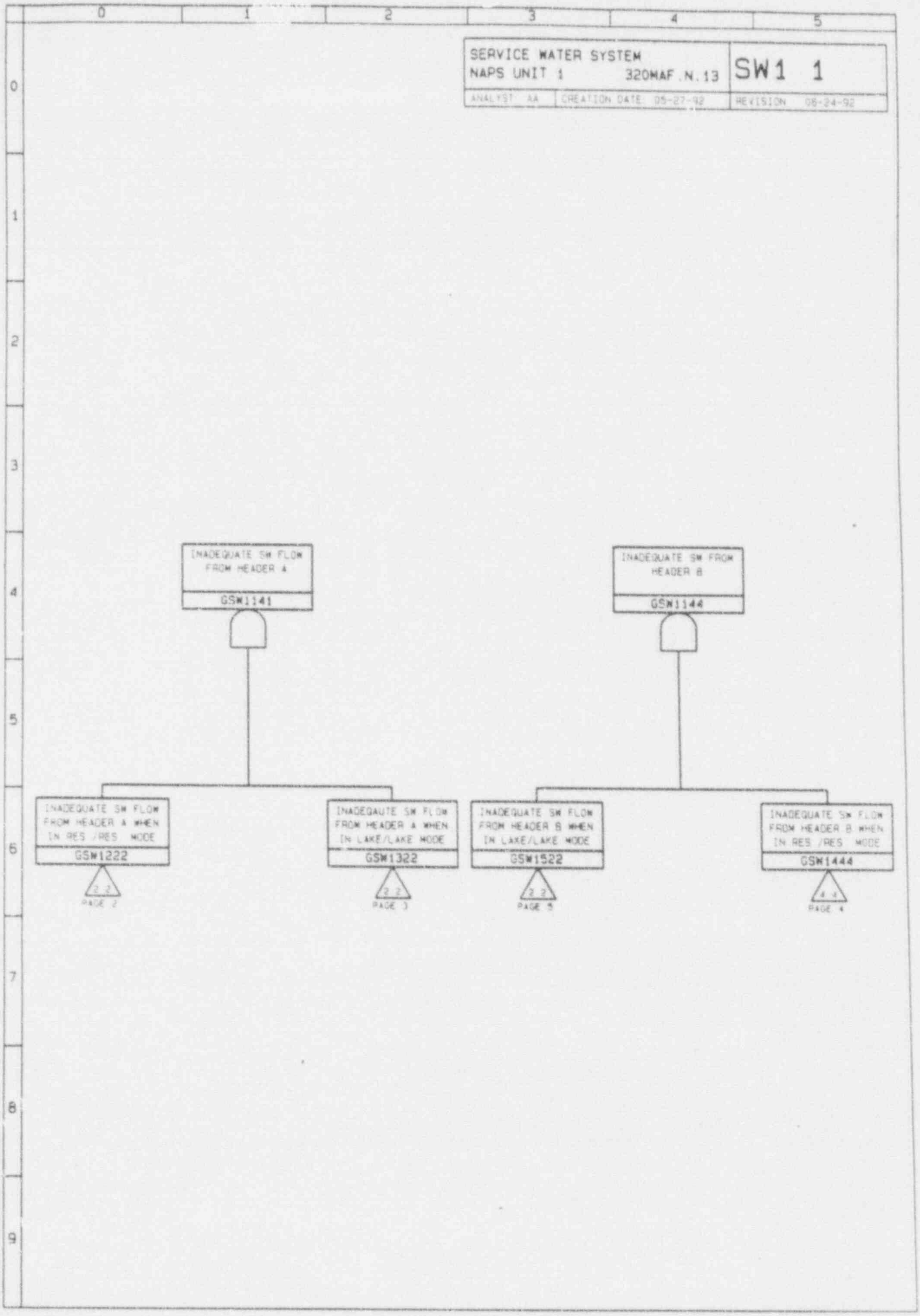
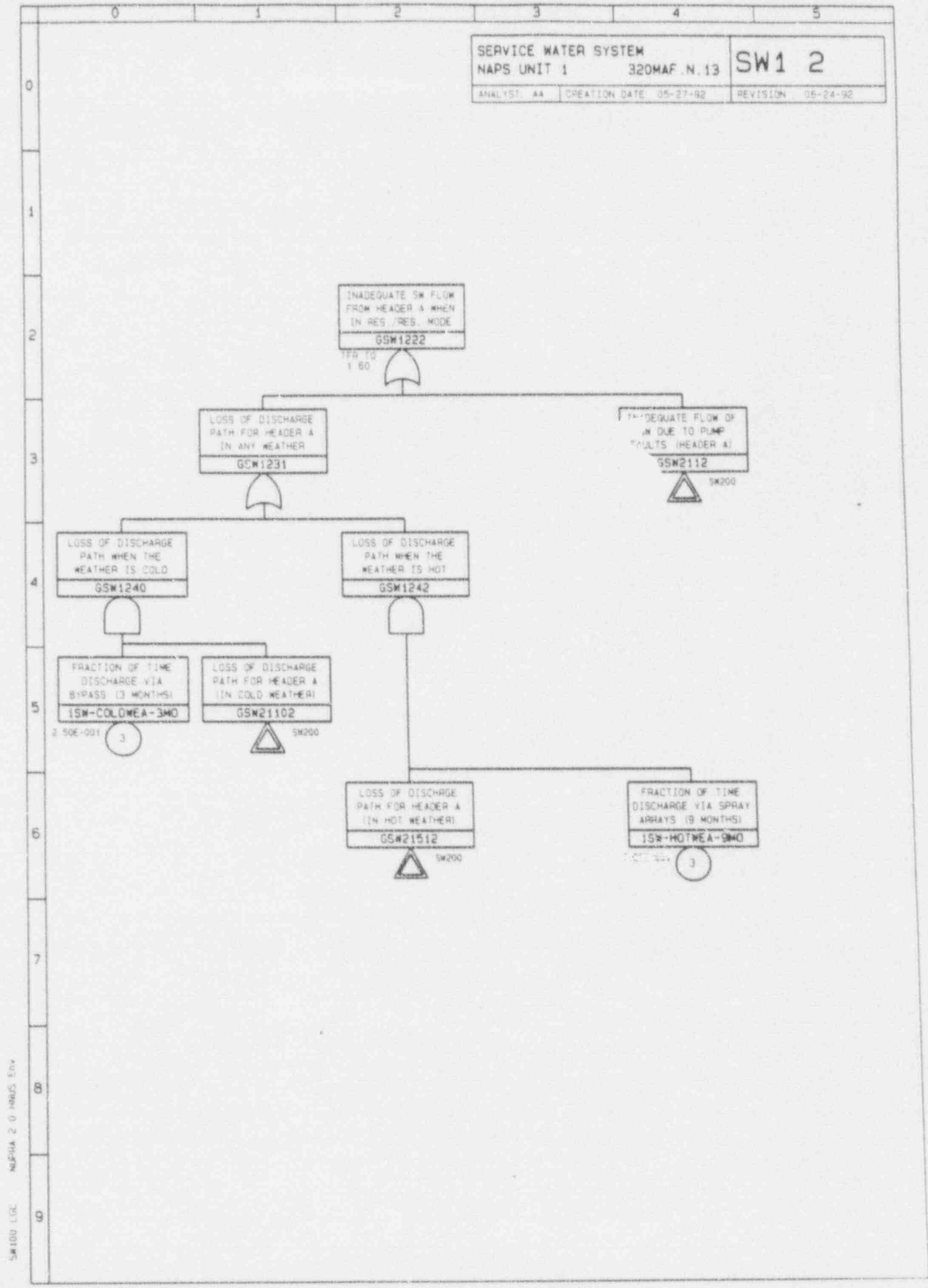
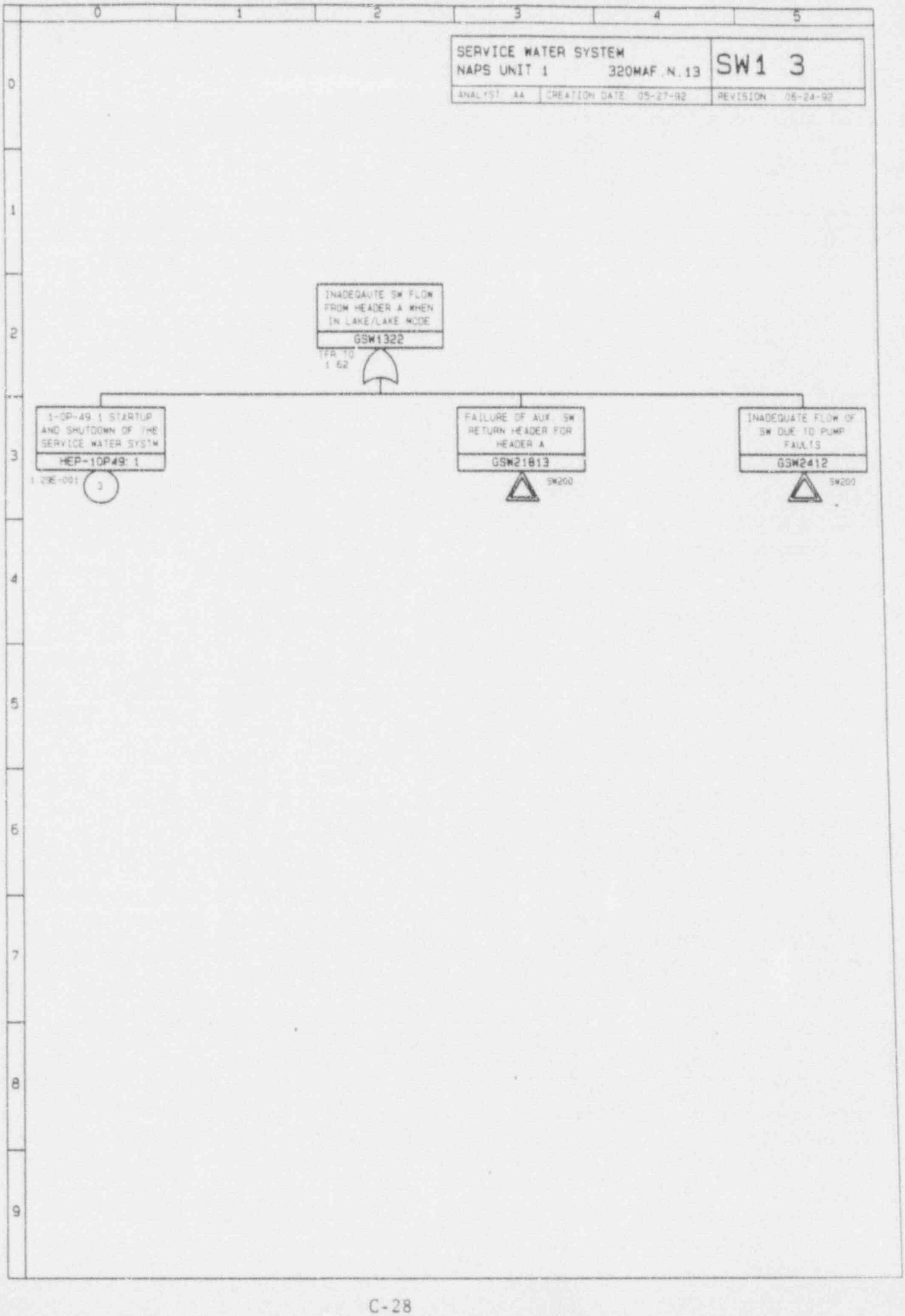
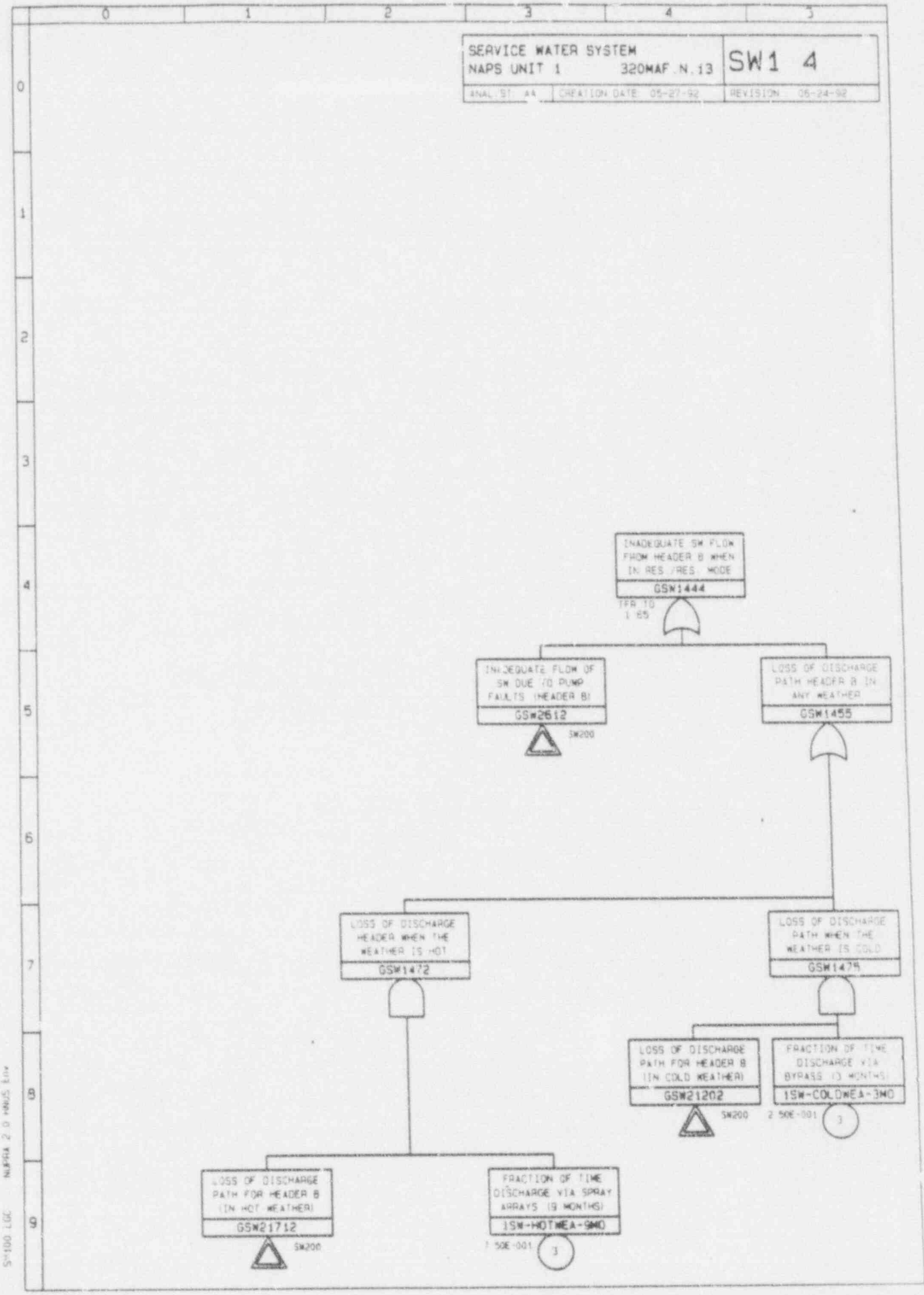


Figure C-2 SW Fault TRee Model

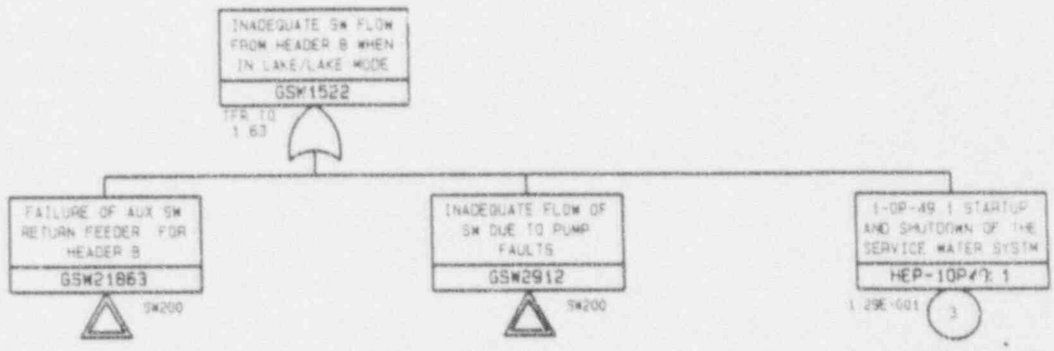

SERVICE WATER SYSTEM
NAPS UNIT 1
320MAF.N.13
SW1 2
ANALYST: AA
CREATION DATE: 05-27-92
REVISION: 05-24-92
INADEQUATE SW FLOW FROM HEADER A WHEN IN RES./RES. MODE
GSW1222
TFR TO 1 60
LOSS OF DISCHARGE PATH FOR HEADER A IN ANY WEATHER
GSW1231
SW200
GSW2112
LOSS OF DISCHARGE PATH WHEN THE WEATHER IS COLD
GSW1240
LOSS OF DISCHARGE PATH WHEN THE WEATHER IS HOT
GSW1242
FRACTION OF TIME DISCHARGE VIA BYPASS (3 MONTHS)
1SW-COLDWEA-3MO
2.50E-001
3
LOSS OF DISCHARGE PATH FOR HEADER A (IN COLD WEATHER)
GSW21102
SW200
LOSS OF DISCHARGE PATH FOR HEADER A (IN HOT WEATHER)
GSW21512
SW200
FRACTION OF TIME DISCHARGE VIA SPRAY ARRAYS (9 MONTHS)
1SW-HOTWEA-9MO
3
SW100 LGC
NUPRA 2 0 HMUS Env

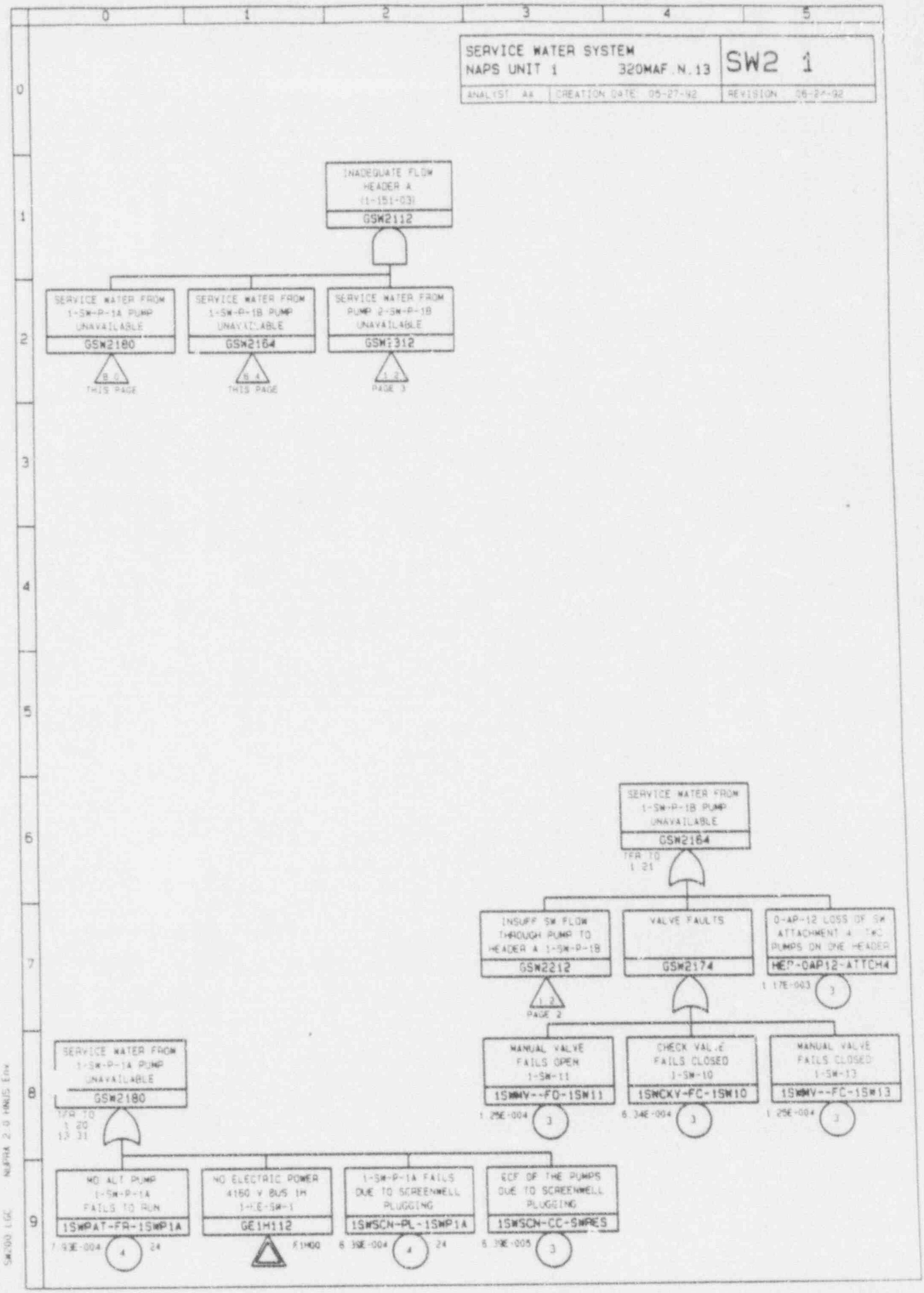

SERVICE WATER SYSTEM
NAPS UNIT 1 320MAF.N.13
SW1 3
ANALYST: AA
CREATION DATE: 05-27-92
REVISION: 06-24-92
INADEQAUTE SW FLOW FROM HEADER A WHEN IN LAKE/LAKE MODE
GSW1322
TFR TO 1 62
1-OP-49.1 STARTUP AND SHUTDOWN OF THE SERVICE WATER SYSTM
HEP-1OP49.1
1.29E-001
3
FAILURE OF AUX. SW RETURN HEADER FOR HEADER A
GSW21813
SW200
INADEQUATE FLOW OF SW DUE TO PUMP FAULTS
GSW2412
SW200



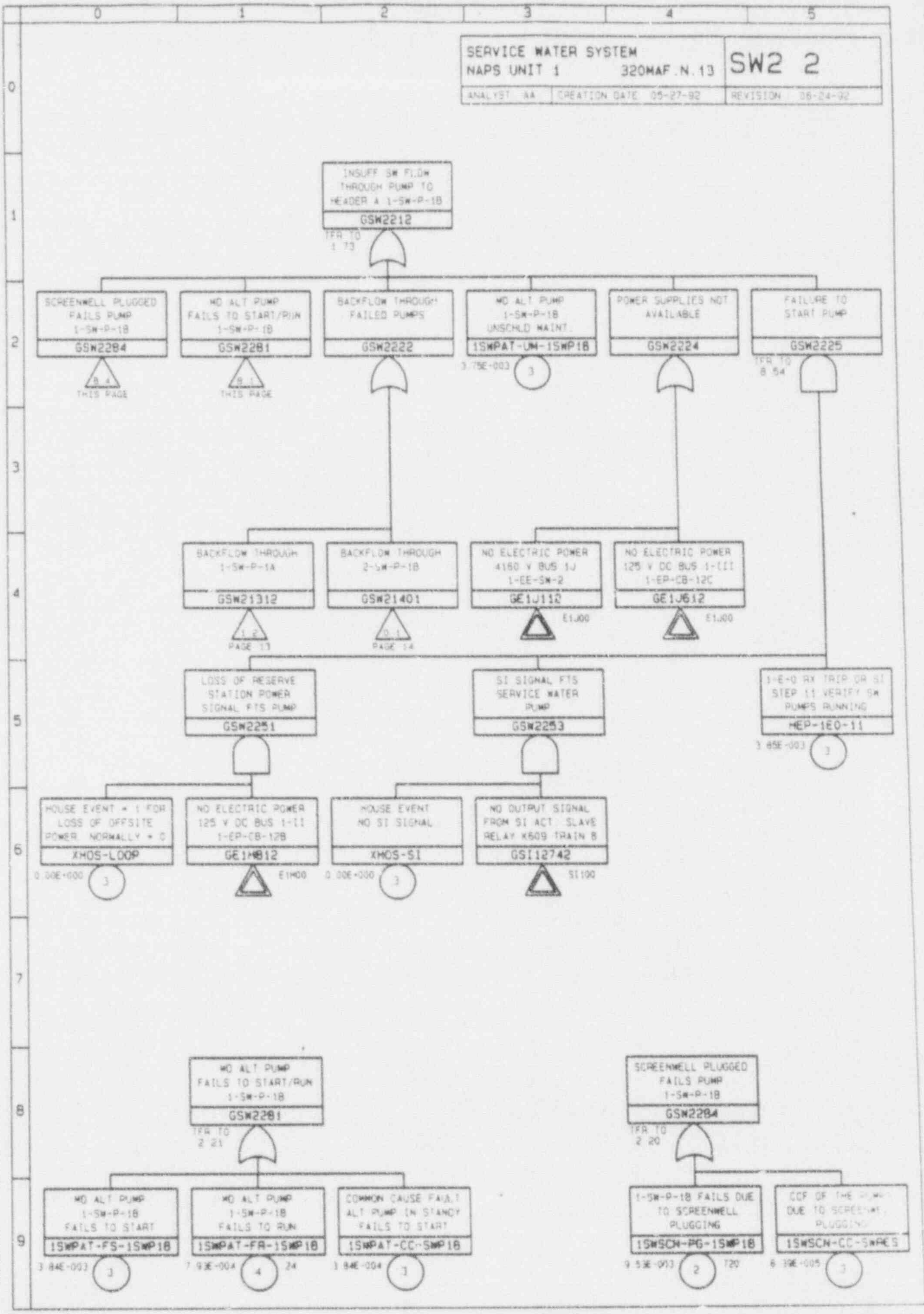
SERVICE WATER SYSTEM
NAPS UNIT 1 320MAF.N.13
SW1 4
ANAL.ST: AA
CREATION DATE: 05-27-92
REVISION: 06-24-92
INADEQUATE SW FLOW FROM HEADER B WHEN IN RES./RES. MODE
GSW1444
TFR TO 1 65
INADEQUATE FLOW OF SW DUE TO PUMP FAULTS (HEADER B)
GSW2612
SW200
LOSS OF DISCHARGE PATH HEADER B IN ANY WEATHER
GSW1455
LOSS OF DISCHARGE HEADER WHEN THE WEATHER IS HOT
GSW1472
LOSS OF DISCHARGE PATH WHEN THE WEATHER IS COLD
GSW1475
LOSS OF DISCHARGE PATH FOR HEADER B (IN COLD WEATHER)
GSW21202
SW200
FRACTION OF TIME DISCHARGE VIA BYPASS (3 MONTHS)
1SW-COLDWEA-3MO
2 50E-001
3
LOSS OF DISCHARGE PATH FOR HEADER B (IN HOT WEATHER)
GSW21712
SW200
FRACTION OF TIME DISCHARGE VIA SPRAY ARRAYS (9 MONTHS)
1SW-HOTWEA-9MO
7 50E-001
3

SERVICE WATER SYSTEM NAPS UNIT 1 320MAF N.13	SW1 5
ANALYST AA / CREATION DATE 05-27-92	REVISION 06-24-92

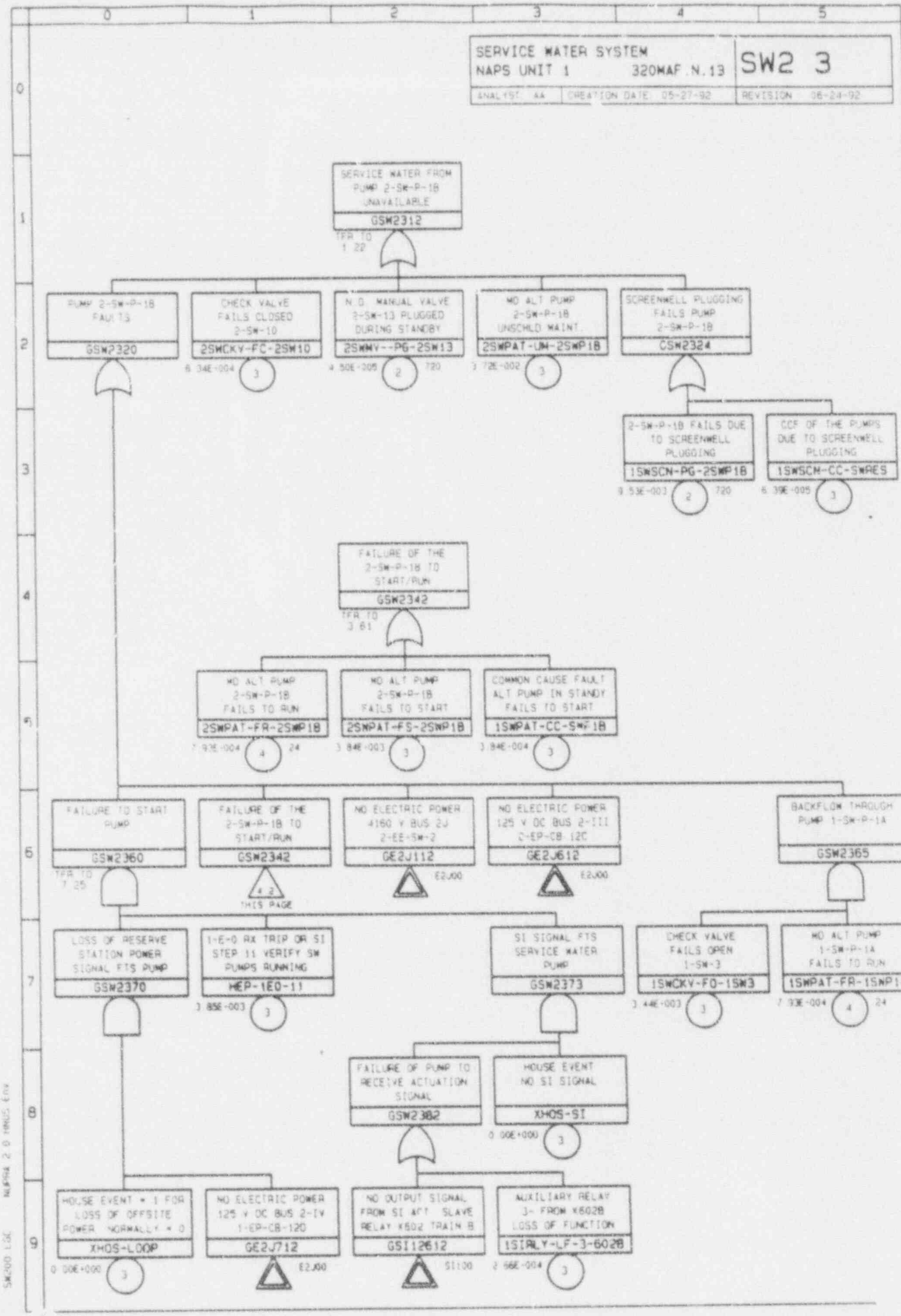


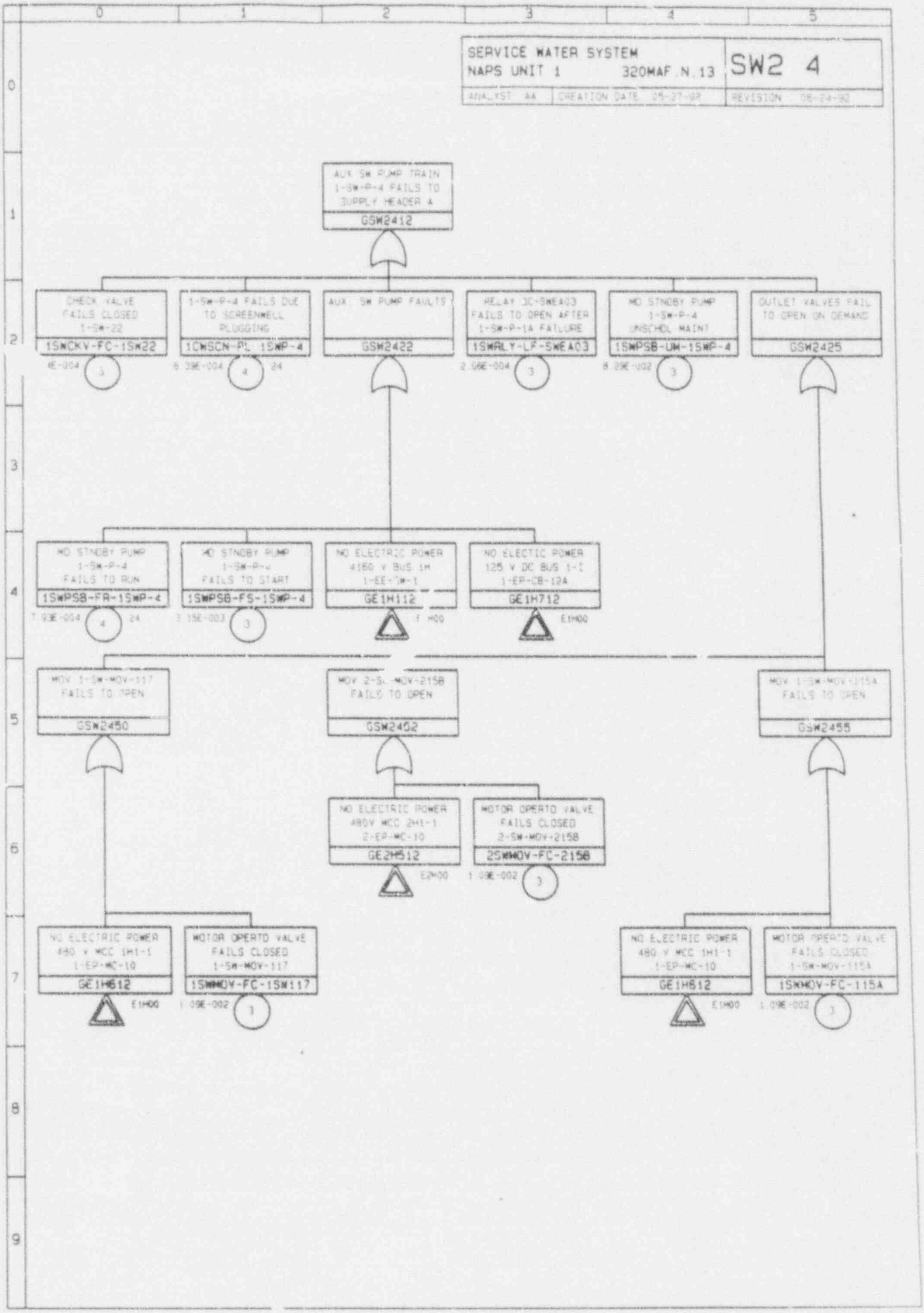


SERVICE WATER SYSTEM
NAPS UNIT 1 320MAF.N.13
SW2 1
ANALYST: AA
CREATION DATE: 05-27-92
REVISION: 08-24-92
INADEQUATE FLOW HEADER A (1-151-03)
GSW2112
SERVICE WATER FROM 1-SW-P-1A PUMP UNAVAILABLE
GSW2180
THIS PAGE
SERVICE WATER FROM 1-SW-P-1B PUMP UNAVAILABLE
GSW2164
THIS PAGE
SERVICE WATER FROM PUMP 2-SW-P-1B UNAVAILABLE
GSW1312
PAGE 3
SERVICE WATER FROM 1-SW-P-1B PUMP UNAVAILABLE
GSW2164
TFR TO 1 21
INSUFF SW FLOW THROUGH PUMP TO HEADER A 1-SW-P-1B
GSW2212
PAGE 2
VALVE FAULTS
GSW2174
0-AP-12 LOSS OF SW ATTACHMENT 4 TWO PUMPS ON ONE HEADER
HEP-0AP12-ATTCH4
1.17E-003
MANUAL VALVE FAILS OPEN 1-SW-11
1SWMV--FO-1SW11
1.25E-004
CHECK VALVE FAILS CLOSED 1-SW-10
1SWCKV-FC-1SW10
6.34E-004
MANUAL VALVE FAILS CLOSED 1-SW-13
1SWMV--FC-1SW13
1.25E-004
SERVICE WATER FROM 1-SW-P-1A PUMP UNAVAILABLE
GSW2180
TFR TO 1 20 13 31
NO ALT PUMP 1-SW-P-1A FAILS TO RUN
1SWPAT-FR-1SWP1A
7.93E-004
NO ELECTRIC POWER 4160 V BUS 1H 1-EE-SW-1
GE1H112
F1H00
1-SW-P-1A FAILS DUE TO SCREENWELL PLUGGING
1SWSCN-PL-1SWP1A
6.39E-004
CCF OF THE PUMPS DUE TO SCREENWELL PLUGGING
1SWSCN-CC-SWRES
6.39E-005
SW200 LGE NUPRA 2.0 HNUS Env



SERVICE WATER SYSTEM
NAPS UNIT 1 320MAF.N.13
SW2 2
ANALYST AA
CREATION DATE 05-27-92
REVISION 06-24-92
INSUFF SW FLOW THROUGH PUMP TO HEADER A 1-SW-P-1B
GSW2212
TFR TO 1 73
SCREENWELL PLUGGED FAILS PUMP 1-SW-P-1B
GSW2284
THIS PAGE
MD ALT PUMP FAILS TO START/RUN 1-SW-P-1B
GSW2281
THIS PAGE
BACKFLOW THROUGH FAILED PUMPS
GSW2222
MD ALT PUMP 1-SW-P-1B UNSCHLD MAINT.
1SWPAT-UM-1SWP1B
3.75E-003
POWER SUPPLIES NOT AVAILABLE
GSW2224
FAILURE TO START PUMP
GSW2225
TFR TO 8 54
BACKFLOW THROUGH 1-SW-P-1A
GSW21312
PAGE 13
BACKFLOW THROUGH 2-SW-P-1B
GSW21401
PAGE 14
NO ELECTRIC POWER 4160 V BUS 1J 1-EE-SW-2
GE1J112
E1J00
NO ELECTRIC POWER 125 V DC BUS 1-III 1-EP-CB-12C
GE1J612
E1J00
LOSS OF RESERVE STATION POWER SIGNAL FTS PUMP
GSW2251
SI SIGNAL FTS SERVICE WATER PUMP
GSW2253
1-E-0 RX TRIP OR SI STEP 11 VERIFY SW PUMPS RUNNING
HEP-1E0-11
3.85E-003
HOUSE EVENT = 1 FOR LOSS OF OFFSITE POWER. NORMALLY = 0
XHOS-LOOP
0.00E+000
NO ELECTRIC POWER 125 V DC BUS 1-II 1-EP-CB-12B
GE1H812
E1H00
HOUSE EVENT NO SI SIGNAL
XHOS-SI
0.00E+000
NO OUTPUT SIGNAL FROM SI ACT. SLAVE RELAY K609 TRAIN B
GSI12742
SI100
MD ALT PUMP FAILS TO START/RUN 1-SW-P-1B
GSW2281
TFR TO 2 21
MD ALT PUMP 1-SW-P-1B FAILS TO START
1SWPAT-FS-1SWP1B
3.84E-003
MD ALT PUMP 1-SW-P-1B FAILS TO RUN
1SWPAT-FR-1SWP1B
7.93E-004
24
COMMON CAUSE FAULT ALT PUMP IN STANDY FAILS TO START
1SWPAT-CC-SWP1B
3.84E-004
SCREENWELL PLUGGED FAILS PUMP 1-SW-P-1B
GSW2284
TFR TO 2 20
1-SW-P-1B FAILS DUE TO SCREENWELL PLUGGING
1SWSCN-PG-1SWP1B
9.53E-003
720
CCF OF THE PUMPS DUE TO SCREENWELL PLUGGING
1SWSCN-CC-SWPES
SW200 LGC NUPRA 2.0 KNUS Eng


SERVICE WATER SYSTEM
NAPS UNIT 1 320MAF.N.13
SW2 3
ANALYST: AA
CREATION DATE: 05-27-92
REVISION: 06-24-92
SERVICE WATER FROM PUMP 2-SW-P-1B UNAVAILABLE
GSW2312
TFR TO 1.22
PUMP 2-SW-P-1B FAULTS
GSW2320
CHECK VALVE FAILS CLOSED 2-SW-10
2SWCKV-FC-2SW10
6.34E-004
N.O. MANUAL VALVE 2-SW-13 PLUGGED DURING STANDBY
2SWMV--PG-2SW13
4.50E-005
720
MD ALT PUMP 2-SW-P-1B UNSCHLD MAINT.
2SWPAT-UM-2SWP1B
3.72E-002
SCREENWELL PLUGGING FAILS PUMP 2-SW-P-1B
GSW2324
2-SW-P-1B FAILS DUE TO SCREENWELL PLUGGING
1SWSCN-PG-2SWP1B
9.53E-003
720
CCF OF THE PUMPS DUE TO SCREENWELL PLUGGING
1SWSCM-CC-SWRES
6.39E-005
FAILURE OF THE 2-SW-P-1B TO START/RUN
GSW2342
TFR TO 3.61
MD ALT PUMP 2-SW-P-1B FAILS TO RUN
2SWPAT-FR-2SWP1B
7.93E-004
24
MD ALT PUMP 2-SW-P-1B FAILS TO START
2SWPAT-FS-2SWP1B
3.84E-003
COMMON CAUSE FAULT ALT PUMP IN STANDY FAILS TO START
1SWPAT-CC-SWP1B
3.84E-004
FAILURE TO START PUMP
GSW2360
TFR TO 7.25
FAILURE OF THE 2-SW-P-1B TO START/RUN
GSW2342
4 2
THIS PAGE
NO ELECTRIC POWER 4160 V BUS 2J 2-EE-SW-2
GE2J112
E2J00
NO ELECTRIC POWER 125 V DC BUS 2-III 2-EP-CB-12C
GE2J612
E2J00
BACKFLOW THROUGH PUMP 1-SW-P-1A
GSW2365
LOSS OF RESERVE STATION POWER SIGNAL FTS PUMP
GSW2370
1-E-0 RX TRIP OR SI STEP 11 VERIFY SW PUMPS RUNNING
HEP-1EO-11
3.85E-003
SI SIGNAL FTS SERVICE WATER PUMP
GSW2373
CHECK VALVE FAILS OPEN 1-SW-3
1SWCKV-FO-1SW3
3.44E-003
MD ALT PUMP 1-SW-P-1A FAILS TO RUN
1SWPAT-FR-1SWP1A
7.93E-004
24
FAILURE OF PUMP TO RECEIVE ACTUATION SIGNAL
GSW2382
HOUSE EVENT NO SI SIGNAL
XHOS-SI
0.00E+000
HOUSE EVENT = 1 FOR LOSS OF OFFSITE POWER, NORMALLY = 0
XHOS-LOOP
0.00E+000
NO ELECTRIC POWER 125 V DC BUS 2-IV 1-EP-CB-12D
GE2J712
E2J00
NO OUTPUT SIGNAL FROM SI ACT. SLAVE RELAY K602 TRAIN B
GSI12612
SI100
AUXILIARY RELAY 3- FROM K602B LOSS OF FUNCTION
1SIRLY-LF-3-602B
2.66E-004



SERVICE WATER SYSTEM
NAPS UNIT 1
320MAF.N.13
SW2 4
ANALYST AA
CREATION DATE 05-27-92
REVISION 06-24-92
AUX SW PUMP TRAIN 1-SW-P-4 FAILS TO SUPPLY HEADER A
GSW2412
CHECK VALVE FAILS CLOSED 1-SW-22
1SWCKV-FC-1SW22
1-SW-P-4 FAILS DUE TO SCREENWELL PLUGGING
1CWSCN-PL 1SWP-4
8.39E-004
24
AUX. SW PUMP FAULTS
GSW2422
RELAY 3C-SWEA03 FAILS TO OPEN AFTER 1-SW-P-1A FAILURE
1SWRLY-LF-SWEA03
2.66E-004
MD STNDBY PUMP 1-SW-P-4 UNSCHDL MAINT
1SWPSB-UM-1SWP-4
8.29E-002
OUTLET VALVES FAIL TO OPEN ON DEMAND
GSW2425
MD STNDBY PUMP 1-SW-P-4 FAILS TO RUN
1SWPSB-FR-1SWP-4
7.93E-004
24
MD STNDBY PUMP 1-SW-P-4 FAILS TO START
1SWPSB-FS-1SWP-4
3.15E-003
NO ELECTRIC POWER 4160 V BUS 1H 1-EE-SW-1
GE1H112
NO ELECTIC POWER 125 V DC BUS 1-I 1-EP-CB-12A
GE1H712
E1H00
MOV 1-SW-MOV-117 FAILS TO OPEN
GSW2450
MOV 2-SW-MOV-215B FAILS TO OPEN
GSW2452
MOV 1-SW-MOV-115A FAILS TO OPEN
GSW2455
NO ELECTRIC POWER 480V MCC 2H1-1 2-EP-MC-10
GE2H512
E2H00
MOTOR OPERTD VALVE FAILS CLOSED 2-SW-MOV-215B
2SWMOV-FC-215B
1.09E-002
NO ELECTRIC POWER 480 V MCC 1H1-1 1-EP-MC-10
GE1H612
E1H00
MOTOR OPERTD VALVE FAILS CLOSED 1-SW-MOV-117
1SWMOV-FC-1SW117
1.09E-002
NO ELECTRIC POWER 480 V MCC 1H1-1 1-EP-MC-10
GE1H612
E1H00
MOTOR OPERTD VALVE FAILS CLOSED 1-SW-MOV-115A
1SWMOV-FC-115A
1.09E-002

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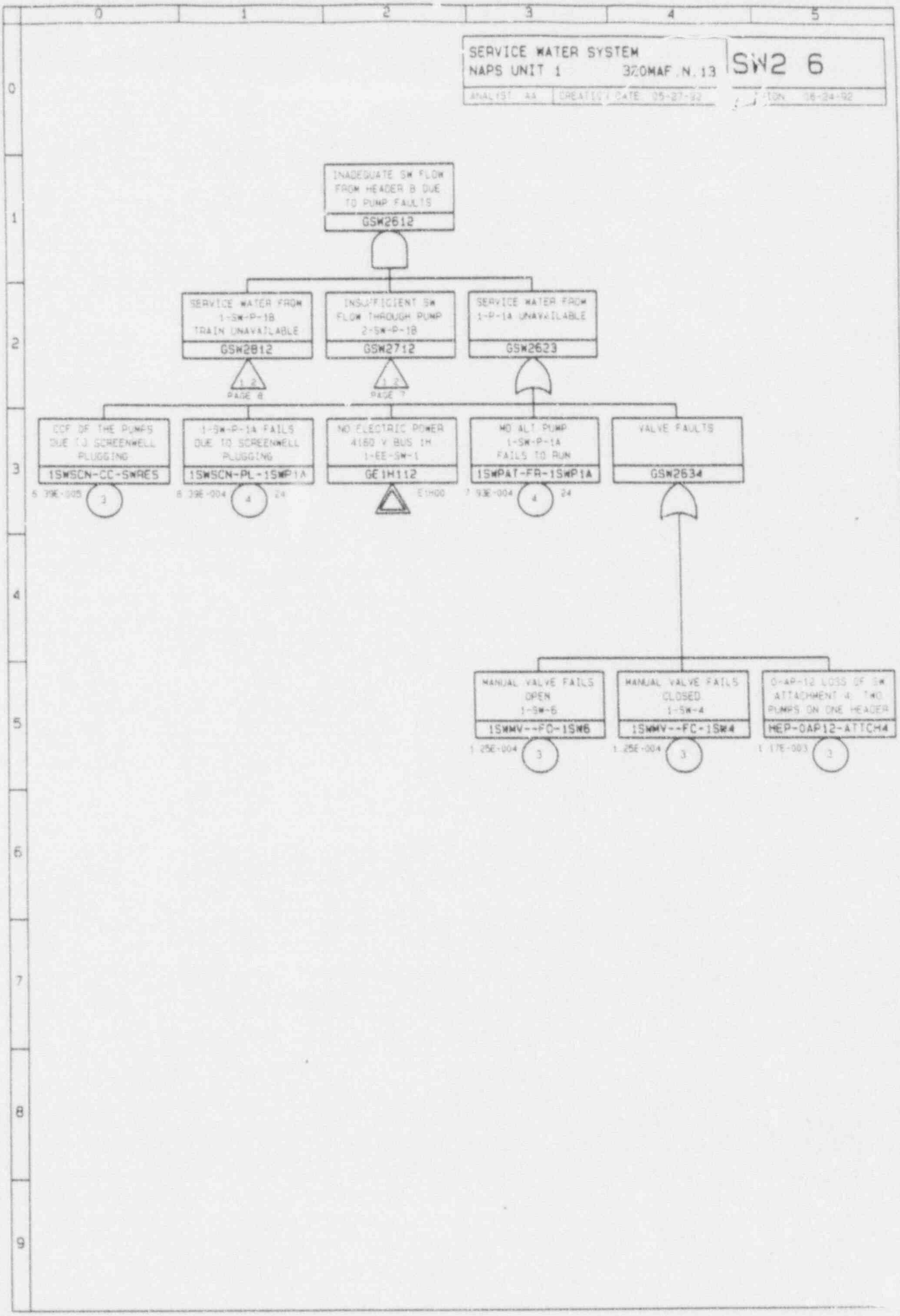
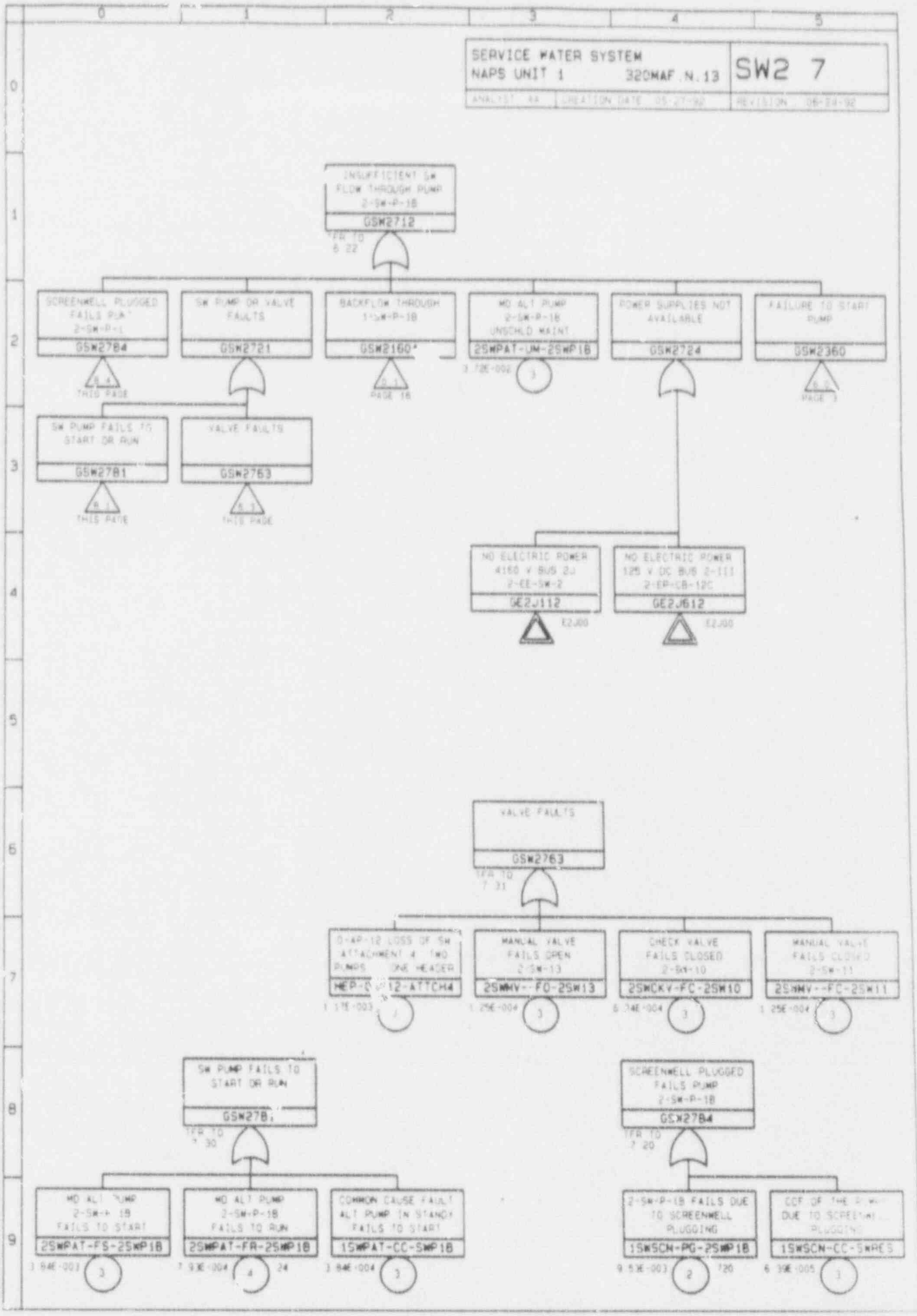
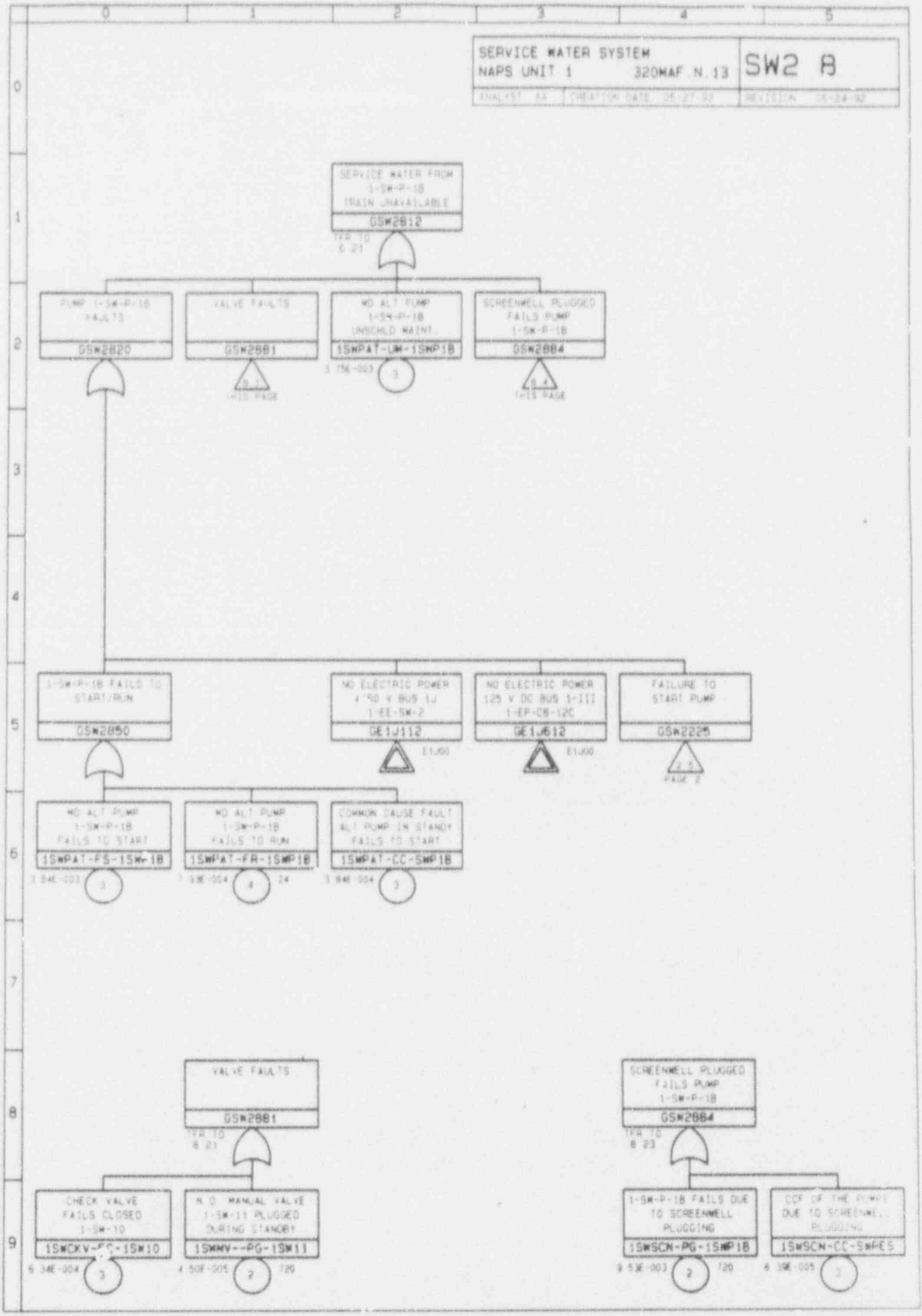
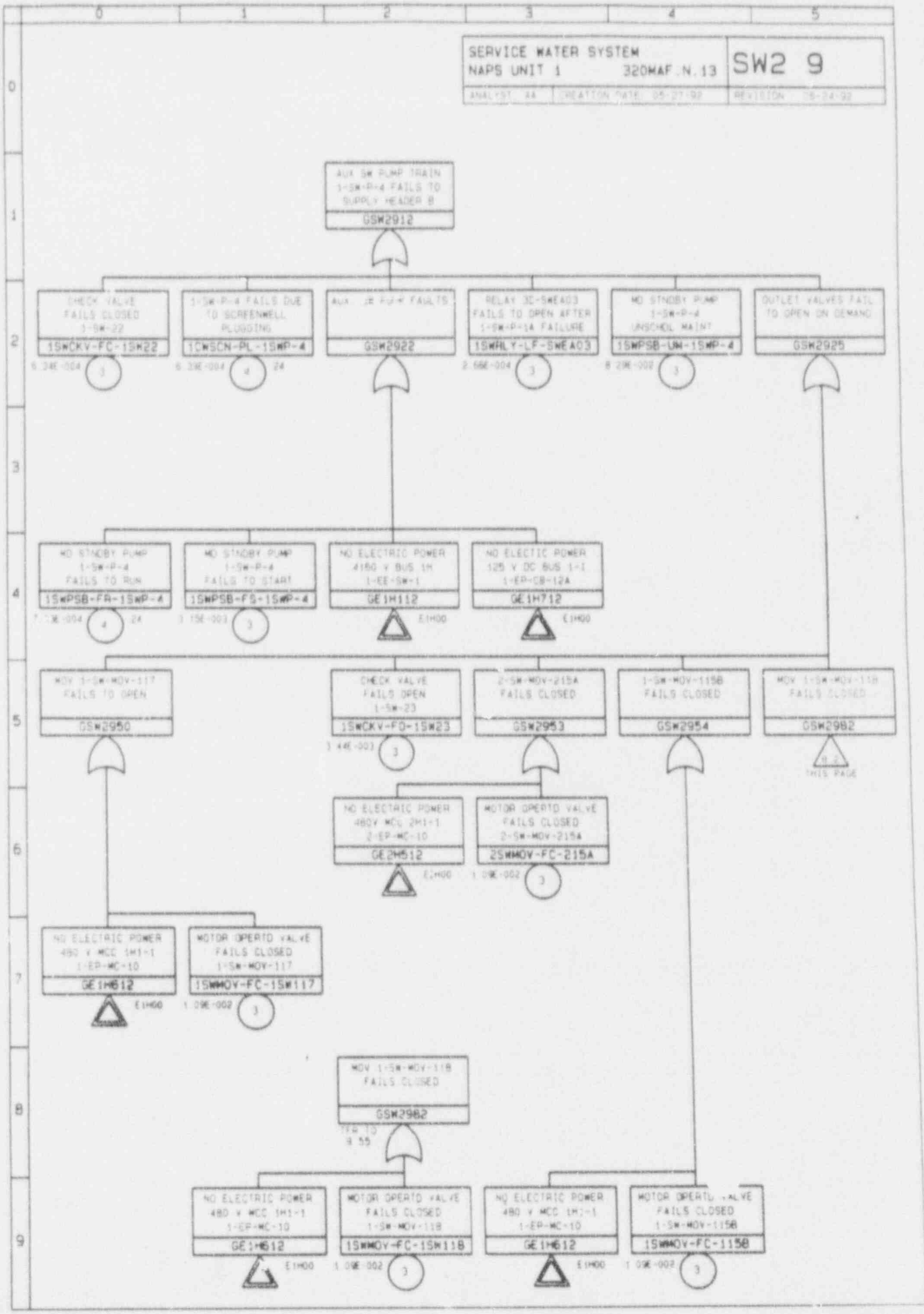

SERVICE WATER SYSTEM
NAPS UNIT 1
320MAF.N.13
SW2 6
ANALYST AA
INADEQUATE SW FLOW FROM HEADER B DUE TO PUMP FAULTS
GSW2612
SERVICE WATER FROM 1-SW-P-1B TRAIN UNAVAILABLE
GSW2812
PAGE 8
INSUFFICIENT SW FLOW THROUGH PUMP 2-SW-P-1B
GSW2712
PAGE 7
SERVICE WATER FROM 1-P-1A UNAVAILABLE
GSW2623
CCF OF THE PUMPS DUE TO SCREENWELL PLUGGING
1SWSCN-CC-SWRES
1-SW-P-1A FAILS DUE TO SCREENWELL PLUGGING
1SWSCN-PL-1SWP1A
NO ELECTRIC POWER 4160 V BUS 1H 1-EE-SW-1
GE1H112
E1H00
MD ALT PUMP 1-SW-P-1A FAILS TO RUN
1SWPAT-FR-1SWP1A
VALVE FAULTS
GSW2634
MANUAL VALVE FAILS OPEN 1-SW-6
1SWMV--FO-1SW6
MANUAL VALVE FAILS CLOSED 1-SW-4
1SWMV--FC-1SW4
0-AP-12 LOSS OF SW ATTACHMENT 4: TWO PUMPS ON ONE HEADER
HEP-0AP12-ATTCH4


SERVICE WATER SYSTEM
NAPS UNIT 1 320MAF.N.13
SW2 7
INSUFFICIENT SW FLOW THROUGH PUMP 2-SW-P-1B
GSW2712
SCREENWELL PLUGGED FAILS PUMP 2-SW-P-1
GSW2784
SW PUMP OR VALVE FAULTS
GSW2721
BACKFLOW THROUGH 1-SW-P-1B
MD ALT PUMP 2-SW-P-1B UNSCHLD MAINT
2SWPAT-UM-2SWP1B
POWER SUPPLIES NOT AVAILABLE
GSW2724
FAILURE TO START PUMP
GSW2360
THIS PAGE
PAGE 16
PAGE 3
SW PUMP FAILS TO START OR RUN
GSW2781
VALVE FAULTS
GSW2763
NO ELECTRIC POWER 4160 V BUS 2J 2-EE-SW-2
GE2J112
NO ELECTRIC POWER 125 V DC BUS 2-III 2-EP-CB-12C
GE2J612
E2J00
VALVE FAULTS
GSW2763
MANUAL VALVE FAILS OPEN 2-SW-13
2SWMV--FO-2SW13
CHECK VALVE FAILS CLOSED 2-SW-10
2SWCKV-FC-2SW10
MANUAL VALVE FAILS CLOSED 2-SW-11
2SWMV--FC-2SW11
SW PUMP FAILS TO START OR RUN
SCREENWELL PLUGGED FAILS PUMP 2-SW-P-1B
MD ALT PUMP 2-SW-P-1B FAILS TO START
2SWPAT-FS-2SWP1B
MD ALT PUMP 2-SW-P-1B FAILS TO RUN
2SWPAT-FR-2SWP1B
COMMON CAUSE FAULT ALT PUMP IN STANDBY FAILS TO START
1SWPAT-CC-SWP1B
2-SW-P-1B FAILS DUE TO SCREENWELL PLUGGING
1SWSCN-PG-2SWP1B
1SWSCN-CC-SWRES



SERVICE WATER SYSTEM
NAPS UNIT 1
320MAF.N.13
SW2 B
SERVICE WATER FROM 1-SW-P-1B TRAIN UNAVAILABLE
GSW2B12
PUMP 1-SW-P-1B FAULTS
GSW2B20
VALVE FAULTS
GSW2BB1
THIS PAGE
MO ALT PUMP 1-SW-P-1B UNSCHLD MAINT.
1SWPAT-UM-1SWP1B
SCREENWELL PLUGGED FAILS PUMP 1-SW-P-1B
GSW2BB4
THIS PAGE
1-SW-P-1B FAILS TO START/RUN
GSW2B50
NO ELECTRIC POWER 125 V DC BUS 1-III
GE1J612
FAILURE TO START PUMP
GSW2225
PAGE 2
MO ALT PUMP 1-SW-P-1B FAILS TO START
1SWPAT-FS-1SW-1B
MO ALT PUMP 1-SW-P-1B FAILS TO RUN
1SWPAT-FR-1SWP1B
COMMON CAUSE FAULT ALT PUMP IN STANDY FAILS TO START
1SWPAT-CC-SWP1B
VALVE FAULTS
GSW2BB1
CHECK VALVE FAILS CLOSED 1-SW-10
N.O. MANUAL VALVE 1-SW-11 PLUGGED DURING STANDBY
1SWMV--PG-1SW11
SCREENWELL PLUGGED FAILS PUMP 1-SW-P-1B
GSW2BB4
1-SW-P-1B FAILS DUE TO SCREENWELL PLUGGING
1SWSCN-PG-1SWP1B
1SWSCN-CC-SWPES


SERVICE WATER SYSTEM
NAPS UNIT 1 320MAF.N.13
SW2 9
AUX SW PUMP TRAIN 1-SW-P-4 FAILS TO SUPPLY HEADER B
GSW2912
CHECK VALVE FAILS CLOSED 1-SW-22
1SWCKV-FC-1SW22
1-SW-P-4 FAILS DUE TO SCREENWELL PLUGGING
1CWSCN-PL-1SWP-4
GSW2922
RELAY 3C-SWEA03 FAILS TO OPEN AFTER 1-SW-P-1A FAILURE
1SWRLY-LF-SWEA03
MD STNDBY PUMP 1-SW-P-4 UNSCHDL MAINT
1SWPSB-UM-1SWP-4
OUTLET VALVES FAIL TO OPEN ON DEMAND
GSW2925
MD STNDBY PUMP 1-SW-P-4 FAILS TO RUN
1SWPSB-FR-1SWP-4
MD STNDBY PUMP 1-SW-P-4 FAILS TO START
1SWPSB-FS-1SWP-4
NO ELECTRIC POWER 4160 V BUS 1H 1-EE-SW-1
GE1H112
E1H00
NO ELECTIC POWER 125 V DC BUS 1-I 1-EP-CB-12A
GE1H712
E1H00
MOV 1-SW-MOV-117 FAILS TO OPEN
GSW2950
CHECK VALVE FAILS OPEN 1-SW-23
1SWCKV-FO-1SW23
2-SW-MOV-215A FAILS CLOSED
GSW2953
1-SW-MOV-115B FAILS CLOSED
GSW2954
MOV 1-SW-MOV-118 FAILS CLOSED
GSW2982
THIS PAGE
NO ELECTRIC POWER 480V MCC 2H1-1 2-EP-MC-10
GE2H512
E2H00
MOTOR OPERTD VALVE FAILS CLOSED 2-SW-MOV-215A
2SWMOV-FC-215A
1.09E-002
NO ELECTRIC POWER 480 V MCC 1H1-1 1-EP-MC-10
GE1H612
E1H00
MOTOR OPERTD VALVE FAILS CLOSED 1-SW-MOV-117
1SWMOV-FC-1SW117
1.09E-002
MOV 1-SW-MOV-118 FAILS CLOSED
GSW2982
NO ELECTRIC POWER 480 V MCC 1H1-1 1-EP-MC-10
GE1H612
E1H00
MOTOR OPERTD VALVE FAILS CLOSED 1-SW-MOV-118
1SWMOV-FC-1SW118
1.09E-002
NO ELECTRIC POWER 480 V MCC 1H1-1 1-EP-MC-10
GE1H612
E1H00
MOTOR OPERTD VALVE FAILS CLOSED 1-SW-MOV-115B
1SWMOV-FC-115B
1.09E-002

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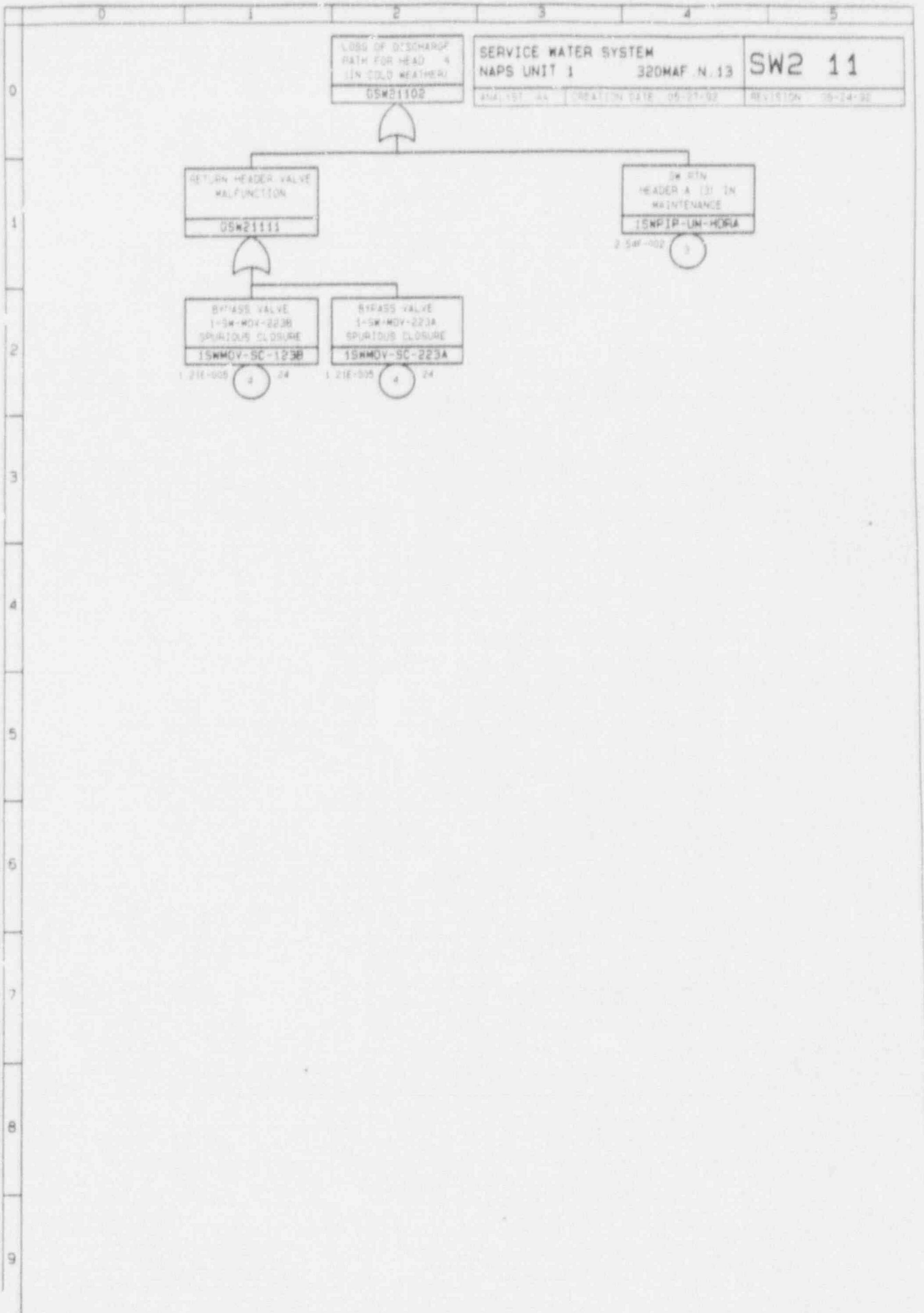
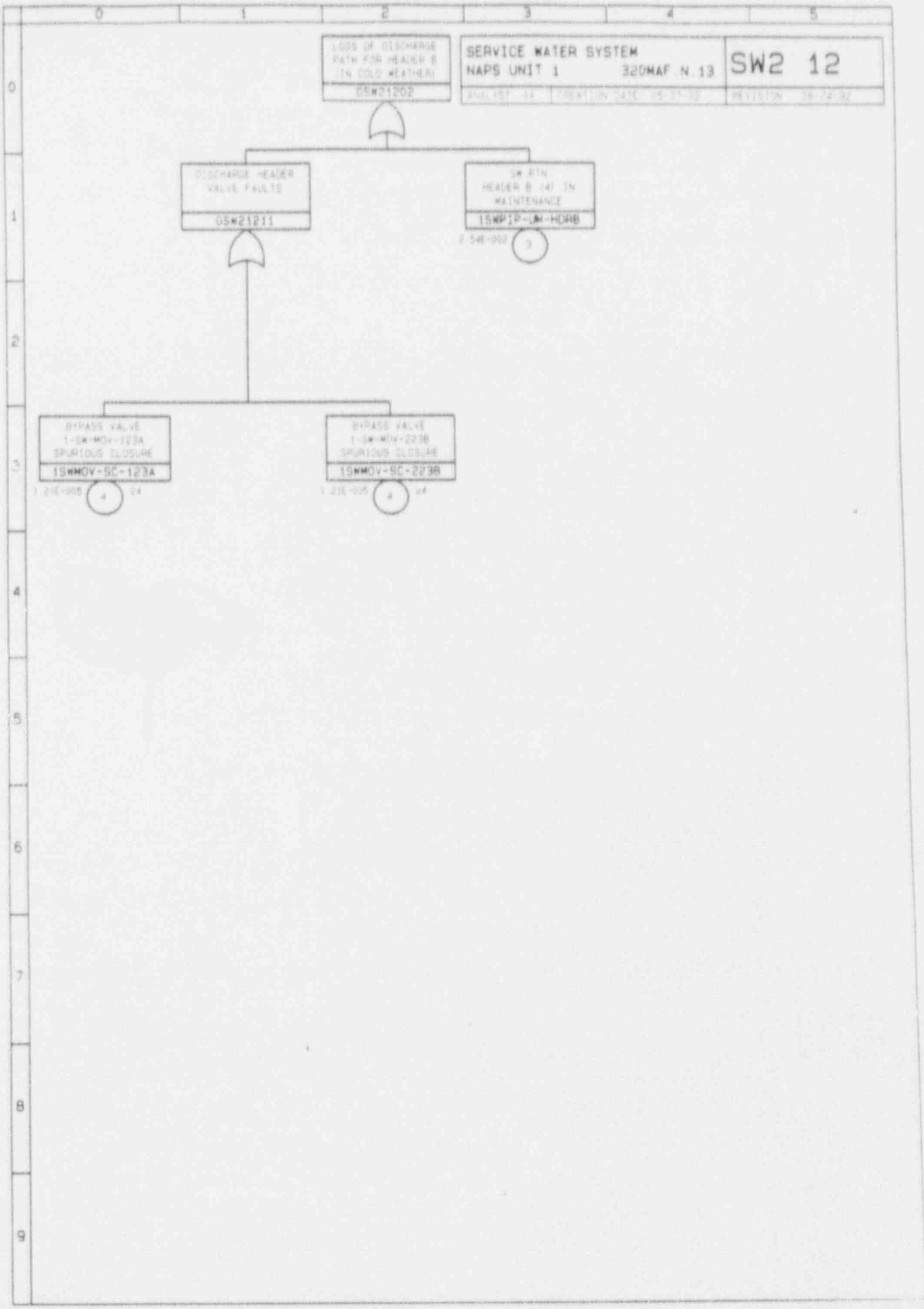
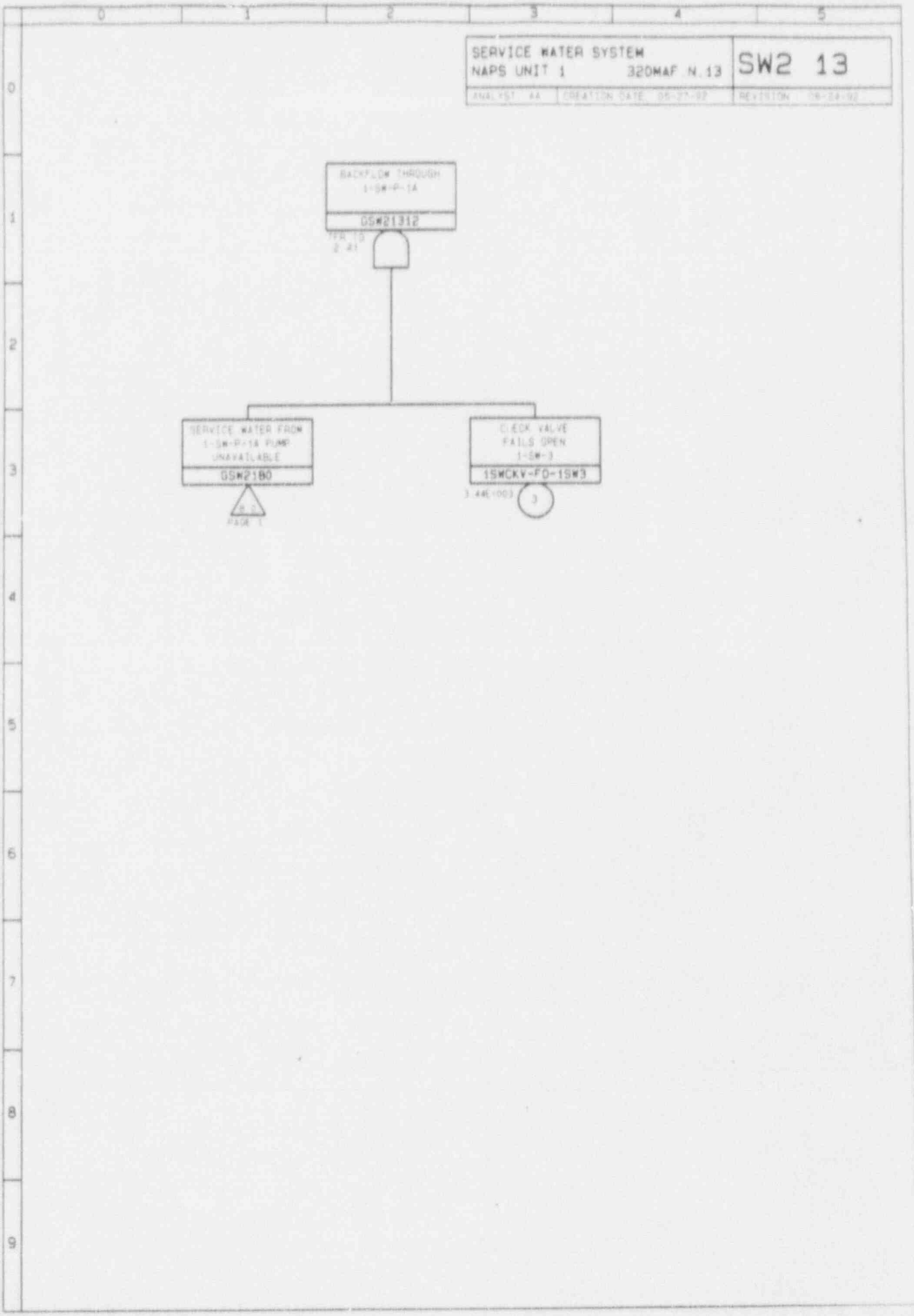

SERVICE WATER SYSTEM
NAPS UNIT 1 320MAF N.13
SW2 11
LOSS OF DISCHARGE PATH FOR HEAD 4 (IN COLD WEATHER)
DSW21102
RETURN HEADER VALVE MALFUNCTION
DSW21111
SW RTN HEADER A (3) IN MAINTENANCE
1SWPIP-UM-HDRA
BYPASS VALVE 1-SW-MOV-223B SPURIOUS CLOSURE
1SWMOV-SC-123B
BYPASS VALVE 1-SW-MOV-223A SPURIOUS CLOSURE
1SWMOV-SC-223A



SERVICE WATER SYSTEM
NAPS UNIT 1 320MAF.N.13
SW2 12
LOSS OF DISCHARGE PATH FOR HEADER B (IN COLD WEATHER)
GSW21202
DISCHARGE HEADER VALVE FAULTS
GSW21211
SW RTN HEADER B (4) IN MAINTENANCE
1SWPIP-UM-HDRB
BYPASS VALVE 1-SW-MOV-123A SPURIOUS CLOSURE
1SWMOV-SC-123A
BYPASS VALVE 1-SW-MOV-223B SPURIOUS CLOSURE
1SWMOV-SC-223B


SERVICE WATER SYSTEM
NAPS UNIT 1 320MAF N.13
SW2 13
ANALYST: AA
BACKFLOW THROUGH 1-SW-P-1A
GSW21312
SERVICE WATER FROM 1-SW-P-1A PUMP UNAVAILABLE
GSW2180
PAGE 1
CHECK VALVE FAILS OPEN 1-SW-3
1SWCKV-FO-1SW3