PACIFIC GAS & ELECTRIC COMPANY

PROBABILISTIC RISK ASSESSMENT

CALCULATION FILE NO. PRA03-12, Rev. 0

SUBJECT: Risk Assessment of Turbine Missiles While Transporting Loaded Casks on the Humboldt Bay Transport Route

PREPARED BY: _____ DATE: 12/8/03
P. Soenen

VERIFIED BY: _____ DATE: 12/8/03
J. Pyo and A. Afzali

VERIFIED IN ACCORDANCE WITH: CF3.ID15

APPROVED BY: _____ DATE: 12/8/03
A. Afzali

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RECORD OF REVISIONS

REV. 0 Original Calculation.

INTRODUCTION

When Humboldt Bay Power Plant (HBPP) moves its spent fuel from the refueling building (RFB), which is located on the plant east side of Unit No. 3, to the Humboldt Bay ISFSI (ISFSI), it will be transporting a loaded HI-STAR HB along the oil supply road and continuing on to the ISFSI. The ISFSI is located on the plant north end of the owner controlled area. While the transporter is in route there is only a very small time period when the transporter is in a direct line of sight to the HBPP turbines, which are located on the plant south side of Unit No. 1 and Unit No. 2. This period of exposure occurs when the transporter is making its turn from the RFB to head up along the oil supply road to the ISFSI. Once the transporter has made this turn it will always have a structure between it and the turbines. The transporter is also only in an unfavorable orientation with respect to the turbines, as defined below, for approximately half of the distance from the RFB to the ISFSI. Please see Figure 1 for the locations of the HBPP turbines, RFB, oil supply road, and ISFSI. However, for the sake of conservatism HBPP has conducted this assessment to show that the hazard rate due to low-trajectory turbine missiles is less than the NRC acceptable upper value.

DISCUSSION

Per Regulatory Guide (RG) 1.115 (Reference 1), the NRC staff considers a hazard rate less than 10^{-7} per year, due to low-trajectory turbine missiles, an acceptable risk rate for the loss of an essential system from a single event. RG 1.115 also states that the protection of an essential system is acceptable if the system and any protecting structure are located outside the low-trajectory missile strike zone, which are defined by ±25-degree lines emanating from the centers of the first and last low-pressure turbine wheels as measured from the plane of the wheels. HBPP assesses the probable risk of a turbine missile occurring, and striking, a loaded HI-STAR HB while it is being transported from the RFB to the ISFSI. The damage probability, or hazard rate, for all of HBPP's fuel transfer to the ISFSI is 1.52×10^{-9}, which is less than the upper value of 10^{-7}.

ACCEPTANCE CRITERIA

Per Regulatory Guide (RG) 1.115, the NRC staff considers a hazard rate less than 10^{-7} per year, due to low-trajectory turbine missiles, an acceptable risk rate for the loss of an essential system from a single event.

ASSUMPTIONS

1. In determining this hazard rate, it is conservatively assumed that the loaded cask on the transporter is in the unfavorable orientation with respect to the turbine, as defined below, for approximately half of the length of the transport route, or 0.125 miles (Reference 2).

2. It is conservatively assumed that each of the 5 fuel transports will be within the low-trajectory missile strike zone for 80 minutes. The transporter is designed to travel at 0.4 mph (Reference 3) and will travel the .125 miles of missile strike zone in approximately 20 minutes. The cask is also conservatively assumed to be in the missile strike zone for an additional hour while it is outside of the RFB and being loaded onto the cask transporter.

3. In this evaluation, per RG 1.115, no shielding of any components by plant structures is credited and 100 percent of the equipment that was struck is assumed to fail to be able to perform its safety-related function.

4. The loaded HI-STAR HB is the only essential system in this situation.

CALCULATIONS

$P_1 \times P_2 \times P_3 = P_4$

P_1 = probability of turbine failure resulting in missiles
P_2 = probability of a missile striking safety-related equipment
P_3 = probability of the equipment that was struck failing to perform its safety-related function
P_4 = damage probability

Electric Power Research Institute (EPRI) Report No. 1006451 (Reference 4) estimated a conservative upper value of 10^{-4} per turbine-year for P_1. This was based on historical failure data obtained from a wide range of turbine sizes (including fossil, nuclear, and industrial units). The HP and LP rotor inspections are performed at the OEM recommended frequency, and the turbine overspeed controls are tested at the recommended frequency.

Provided by EPRI Report No. 1007637 (Reference 5), in performing turbine missile risk analysis in accordance with RG 1.115, the conditional probability of a missile strike and damage to a safety related piece of equipment ($P_2 \times P_3$) in the event of missile generation has an upper bound of 10^{-2} for unfavorable turbine orientation. Equipment is considered to be unfavorably oriented if it is located within the area bounded by lines inclined at 25 degrees to the turbine wheel planes and passing through the end wheels of the low-pressure stages of the turbine as described in RG 1.115 (see Figure 1 of Reference 1).

$P_1 = 10^{-4}$ (per turbine-year)

$P_2 \times P_3 = 10^{-2}$ (per turbine-year)

$P_1 \times P_2 \times P_3 = 10^{-4} \times 10^{-2} = P_4$

$P_4 = 10^{-6}$ (per turbine-year)

1 year = 8760 hours

$P_4 = 1.14 \times 10^{-10}$ (per turbine-hour)

A loaded cask will be in the missile strike zone for approximately 1.33 hours per cask, for a total of 5 casks.

$P_4 \times 5 \times 1.33$ hours $= 1.14 \times 10^{-10} \times 5 \times 1.33$ hours $= 7.58 \times 10^{-10}$

There are two operating turbines at HBPP, and therefore this risk probability must be multiplied by two.

$P_4 \times 2 = 1.52 \times 10^{-9}$

RESULTS

The damage probability for all of HBPP's fuel transfer to the ISFSI is 1.52×10^{-9}, which is less than the upper value of 10^{-7} required by RG 1.115 to be an acceptable risk rate.

REFERENCES

1. Regulatory Guide 1.115, Protection Against Low-Trajectory Turbine Missiles, US Nuclear Regulatory Commission, July 1977.

2. Enercon Drawing SK-HBISFSI-005, Revision 0.

3. Humboldt Bay ISFSI Safety Analysis Report, Table 3.4-4, Initial Submittal, December 2003.

4. EPRI Report No. 1006451, Technical Approach to Turbine Missile Probability Assessment, Palo Alto, CA; December 2001.

5. EPRI Report No. 1007637, Risk-Informed Turbine Missile Analysis for a BWR 4, Palo Alto, CA; February 2003.

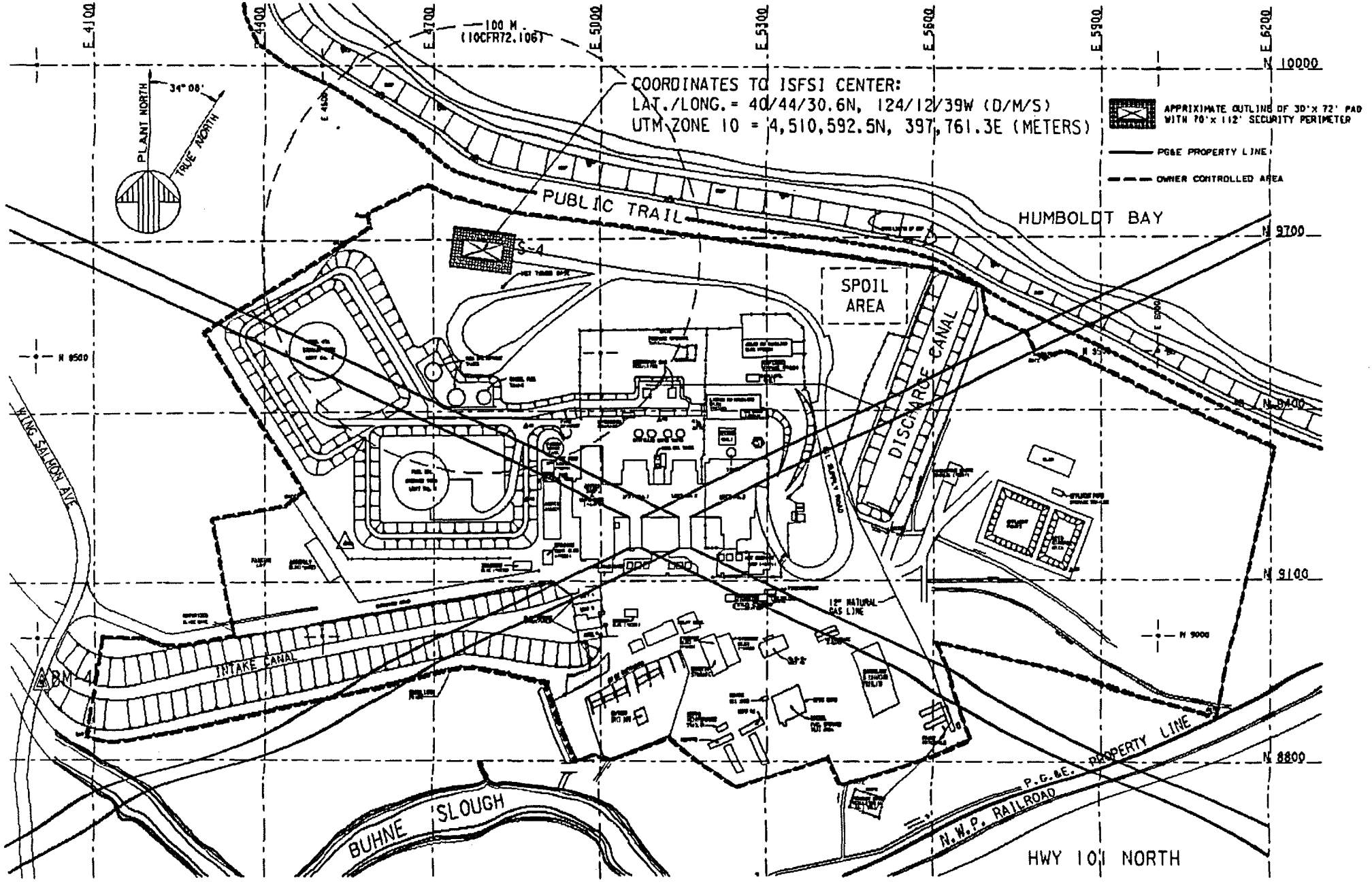

FIGURE 1
HBPP SITE PLAN