UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
GE-HITACHI GLOBAL LASER ENRICHMENT LLC	)	Docket No. 70-7016-ML
	)	
	)	ASLBP No. 10-901-03-ML-BD01
(GLE Commercial Facility)	)	
	)	

NRC STAFF TESTIMONY RELATED TO TOPIC 3:
SAFETY IMPACT OF EXTERNAL HAZARDS

Q1: Please state your name, occupation, employer, and your professional qualifications.

A1: (JS) My name is Dr. John A. Stamatakos. I am the Director of Technical Programs at the Center for Nuclear Regulatory Analyses (CNWRA®), Geosciences and Engineering Division (GED), Southwest Research Institute (SwRI®). The CNWRA is the U.S. Nuclear Regulatory Commission's (NRC) federally funded research and development center. A statement of my professional qualifications is attached.

A1: (AC) My name is Dr. Asadul H. Chowdhury. I am a Staff Engineer at the CNWRA. A statement of my professional qualifications is attached.

A1: (SH) My name is Sui-Min (Simon) Hsiung. I am also a Staff Engineer at the CNWRA. A statement of my professional qualifications is attached.

Q2: Please describe your responsibilities with regard to the safety review of the license application for the proposed GE-Hitachi Laser Enrichment LLC (GLE) Facility in Wilmington, North Carolina.

A2: (JS) I was the primary reviewer of GLE's seismic hazard assessment [ISA Summary Section 2.5.1 (Earthquakes)]. My evaluation of the seismic hazard assessment is provided in Section 1.2.2.4.1 (Seismic Hazards), and Section 3.3.4.10 (Geologic and Seismic Events) of the NUREG 2120, "Safety Evaluation Report for the General Electric-Hitachi Global

Laser Enrichment LLC Laser-Based Uranium Enrichment Plant in Wilmington, North Carolina" (SER) (Ex. NRC001). I also supported the reviews of GLE's evaluation of hazards related to other natural phenomena (e.g., tsunamis) and GLE's seismic hazard and design evaluations to ensure that the seismic information was used appropriately and consistently. These reviews are documented in Sections 3.3.4.2 (Hurricane and Tsunami), 1.2.2.4.1 (Seismic Hazards), 3.3.4.10 (Geology and Seismic Events), and 3.3.12 (IROFS Structures Review) of the SER (Ex. NRC001).

A2: (AC) I was the primary reviewer of GLE's items relied on for safety (IROFS) structural analysis and design. My review and evaluation are provided in Section 3.3.12 (IROFS Structures Review) of the SER (Ex. NRC001). I also supported the reviews of GLE's evaluation of external hazards due to seismic, high winds and tornadoes, and flooding, including hurricanes and tsunamis, to ensure that the external hazards information was used appropriately and consistently to develop the design bases. These reviews are documented in Sections 1.2.2.4.1 (Seismic Hazards), 3.3.4.10 (Geology and Seismic Events), 1.3.3.3.1 (Tornado Hazard), 1.3.3.3.2 (High Winds and Hurricanes), 1.3.3.3.7 (Floods), 1.3.3.3.8 (Tsunami), 3.3.4.1 (High Wind and Tornado Hazards), 3.3.4.2 (Hurricane and Tsunami), and 3.3.4.4 (Flooding) of the SER (Ex. NRC001).

A2: (SH) I was the primary reviewer of GLE's assessment of external hazards for the proposed GLE Facility other than seismic hazards. My review included the assessment of hazards due to flooding, including hurricanes and tsunamis, and hazards due to high winds and tornados. My analysis of GLE's assessments of these hazards is documented in Sections 1.3.3.3.1 (Tornado Hazard), 1.3.3.3.2 (High Winds and Hurricanes), 1.3.3.3.7 (Floods), 1.3.3.3.8 (Tsunami), 3.3.4.1 (High Wind and Tornado Hazards), 3.3.4.2 (Hurricane and Tsunami), and 3.3.4.4 (Flooding) of the SER (Ex. NRC001).

Q3: What is the purpose of your testimony?

A3: (JS, AC, SH) To review GLE's external hazards evaluations related to flooding, high winds and tornadoes, and earthquakes, and to provide a more expansive explanation of the NRC staff's rationale for concluding that, in its evaluation, GLE (i) characterized these hazards with sufficient detail to support assessment of their impacts on facility safety and to assess their likelihood of occurrence, (ii) identified all design basis natural events, (iii) provided bases for incredible events identified, and (iv) assessed events that could occur without adversely impacting safety. The guidance used to assess the potential safety impact is discussed in the response to Question 6 below.

External Hazards

Q4: What are external hazards?

A4: (JS, AC, SH) External hazards are natural and human-induced events that originate outside the site boundaries of the facility and that may affect the safety of the site and the facility. The facility operator has little or no control over these events. External hazards can be safety-significant contributors to the risk of facility operations.

Human-induced hazards include accidental aircraft crashes or explosions at nearby facilities or on nearby transportation routes. The Staff's review of GLE's human-induced hazard assessments for the proposed GLE facility is documented in Sections 3.3.4.6 (Nearby Highways), 3.3.4.7 (Railroads), 3.3.4.8 (Nearby Industrial Facilities), and 3.3.4.9 (Air Transportation) of the SER (Ex. NRC001).

Natural phenomena hazards include earthquakes, tsunamis, volcanic activity, high wind and tornados, storms, floods, landslides, settlement, and liquefaction. The Staff review of GLE's natural phenomena hazard assessments is documented in the following sections of the SER (Ex. NRC001): 3.3.4.1 (High Wind and Tornado Hazards), 3.3.4.2 (Hurricanes and Tsunami), 3.3.4.3 (Extreme Rainfall), 3.3.4.4 (Flooding), 3.3.4.5 (Snow), 3.3.4.10 (Geology and Seismic

Events), 3.3.4.11 (Slope Stability), 3.3.4.12 (Liquefaction), and 3.3.4.13 (Settlement and Soil-Bearing Capacity).

The testimony that follows will focus on natural phenomena hazards related to flooding (including hurricanes and tsunamis), high winds and tornados, and earthquakes.

Regulatory Requirements and Guidance Documents

Q5: What are the regulatory requirements that must be met with respect to natural phenomena hazards?

A5: (JS, AC, SH) The license application for the proposed GLE Facility must meet the following regulatory requirements related to natural phenomena hazards:

- 10 CFR 70.61(a) requires an applicant to evaluate, in the integrated safety analysis (ISA), its compliance with the performance requirements in 10 CFR 70.61(b) and (c) to reduce the risk of events that could have significant impacts to workers or the public. Specifically, 10 CFR 70.61(b) requires high consequence events to be highly unlikely and 10 CFR 70.61(c) requires intermediate consequence events to be unlikely.
- 10 CFR 70.62(c)(iv) requires an applicant to assess in its ISA potential accident sequences caused by credible external events, including natural phenomena.
- 10 CFR 70.64(a)(2) requires the facility design to provide adequate protection against natural phenomena with consideration of most severe documented historical events for the site.
- 10 CFR 70.65(b)(1) requires an applicant to provide, in its ISA Summary, a general description of the site with emphasis on factors that could affect safety (i.e., meteorology, seismology).

In order to approve the license application, the NRC Staff must determine, pursuant to 10 CFR 70.23(a)(4), that the applicant's proposed equipment and facilities are adequate to protect

health and minimize danger to life or property. The Staff must also determine, pursuant to 10 CFR 70.66(a), that the applicant has complied with the requirements listed above.

Q6: What are the guidance documents the staff used to conduct its review of natural phenomena hazards related to flooding, high winds and tornados, and earthquakes?

A6: (JS, AC, SH) The Staff used the acceptance criterion in Section 3.4.3.2(1)(c) of NUREG-1520, "Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility" (Rev. 0, March 2002) (Ex. NRC005) to guide its review of flooding, high wind and tornado, and earthquake hazards. This acceptance criterion states that the Staff should determine whether the applicant (i) characterized these hazards with sufficient detail to support assessment of their impacts on facility safety and to assess their likelihood of occurrence, (ii) identified all design basis natural events, (iii) indicated which events are considered incredible and provided bases for those determinations; and (iv) assessed events that could occur without adversely impacting safety.

Interim Staff Guidance (ISG) FCSS-ISG-08, "Natural Phenomena Hazards," (Ex. NRC036) provides further guidance for conducting the review of natural phenomena hazards. FCSS-ISG-08 specifies that, for natural phenomena, deterministically defined events such as the probable maximum flood or safe shutdown earthquake (used as nuclear power plant design bases) can be used in place of purely probabilistically determined "highly unlikely" events and may be preferable, depending on the quality of historical data. This ISG further states that a site meeting the flood protection requirements of a commercial reactor should be considered as being designed or located adequately to withstand a "highly unlikely" flooding event. FCSS-ISG-08 accepts the design-basis flood (which for river sites is the probable maximum flood) as described in Regulatory Guide 1.59, "Design Basis Floods for Nuclear Power Plants," (Ex. NRC029) to have an exceedance frequency of less than 10^{-5}/year.

Furthermore, FCSS-ISG-08 indicates the need to consider the effects of a tornado with an annual exceedance probability of 10^{-5} or greater. Based on FCSS-ISG-08, potential damage

to and/or failure of items relied on for safety (IROFS) as the result of earthquake ground movement and/or the seismic response of adjacent or interior IROFS must be considered in the ISA and ISA Summary accident sequence evaluations.

In addition to NUREG-1520 and FCSS-ISG-08, the Staff also used other applicable NRC guidance documents to conduct the review of natural phenomena hazards related to flooding (including hurricanes and tsunamis), high winds and tornados, and earthquakes. Specifically, the staff used Regulatory Guide (RG) 1.59, “Design Basis Floods for Nuclear Power Plants,” (Ex. NRC029) to review GLE’s evaluation of flooding potential at the facility site resulting from hurricanes, and NUREG/CR-4461, “Tornado Climatology of the Contiguous United States,” (Ex. NRC030) to review GLE’s assessment of tornado hazards.

The Staff also used well-established codes and standards from external sources, particularly U.S. Department of Energy (DOE) Standard 1020-2002, “Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities,” to evaluate GLE’s assessment of seismic hazards; and American Society of Civil Engineers (ASCE) 43-05, “Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities,” American Institute of Steel Construction (AISC) N690, “Specification for Safety-Related Steel Structures for Nuclear Facilities,” ASCE 7-05, “Minimum Design Loads for Buildings and Other Structures,” and American Concrete Institute (ACI) ACI-349, “Code Requirements for Nuclear Safety-Related Concrete Structures (ACI 349-06) and Commentary” to review GLE’s design of IROFS structures against flooding (including hurricanes and tsunamis), high winds and tornados, and earthquakes hazards.

Flooding Hazards

Q7: Briefly review the Applicant’s flooding hazard evaluation.

A7: (JS, SH) GLE discussed its flooding hazard evaluation in ISA Summary Sections 2.5.3 (Floods), 2.5.4 (Tsunami), and 2.5.5 (Hurricanes) (Ex. GLE010). The flooding hazard at

the proposed Laser Enrichment Facility site was evaluated on the basis of rainfall in the Northeast Cape Fear River and the Cape River Fear watersheds, locally heavy site rainfall, and hurricane surge. GLE characterized the potential flooding hazards from the rainfall in the river watersheds using the probable maximum flood, the local severe rainfall using the probable maximum precipitation, and hurricane surge using the probable maximum hurricane surge. GLE assessed potential flooding due to the effects of tsunamis considering the distance of the site relative to the nearest coastline and the elevation of the site relative to mean sea level.

The nearest river to the proposed GLE Facility site is the Northeast Cape Fear River, which joins the Cape Fear River 9.7 km (6 mi) south of the site. GLE determined that the Northeast Cape Fear River has a discharge capability of 2,549–14,442 cubic meters per second (m^3/sec) [90,000–510,000 cubic feet per second (cfs)] and a PMF discharge of 8,778 m^3/sec (310,000 cfs). The probable maximum flood discharge from the Cape Fear River is about twice the discharge from the Northeast Cape River. Both rivers could potentially affect the proposed facility site. The proposed facility site is located more than 16 km (10 mi) inland from the Atlantic Ocean. The site and the surrounding area are relatively flat with gently sloping surfaces at gradients less than 2 percent and with little relief. In addition, the proposed facility is located 7.6 m (25 ft) above mean sea level. This elevation is, in general, the highest level east of the Northeast Cape Fear River. The east side of the Northeast Cape Fear River extends all the way to the coast. The elevation west of the river is also at 7.6 m (25 ft) above mean sea level for some distance before the elevation gets higher further west. Because of this general level terrain around the Northeast Cape Fear River, the rise of flood level above the 7.6 m (25 ft) above mean sea level will be limited and will be a slow process due to the availability of large flat region to accommodate the flood water. GLE indicated that it is difficult to determine the discharge when the water level reaches 7.6 m (25 ft) above mean sea level due to the wide variability of the cross sections of the Northeast Cape Fear River above that level. Nevertheless, GLE estimated that, including coincident wind-wave effects, the design basis

water level for the probable maximum flood is 8.5 m (28 ft) above mean sea level for the proposed facility site, which is 0.9 m (3 ft) above the proposed facility floor level. Because the rise in water level during a probable maximum flood will be a slow process, ample time will be available for the operations personnel to take mitigating actions.

No upstream dams exist on the Northeast Cape Fear River. Several dams exist upstream on the Cape Fear River. These dams are 48 km (30 mi) or more distant from where the Northeast Cape Fear River joins the Cape Fear River. Seismically induced dam failure could cause flooding of the proposed facility site; however, the Applicant determined and the Staff agreed that such floods could not result in a flooding level more than the probable maximum flood because of the general level terrain surrounding the area and the availability of large flat region to accommodate flood waters.

The recorded maximum rainfall event from Hurricane Floyd on September 15, 1999 for a 24-hour duration is 34 cm (13.38 in). GLE estimated that the probable maximum precipitation for the Northeast Cape Fear River Basin corresponding to 24-, 48-, and 72-hour durations were 66 cm (26 in), 76 cm (30 in), and 82.6 cm (32.5 in), respectively. Because the proposed GLE Facility is located at 7.6 m (25 ft) above mean sea level, a local high point relative to the surrounding areas, this rainfall will drain in all directions to lower elevations. Therefore, GLE concluded that the probable maximum precipitation will not flood the facility site.

Q8: Expand on the rationale behind the NRC Staff's conclusion that the evaluation of flooding hazards was acceptable.

A8: (JS, AC, SH) The Staff's evaluation of the design basis flood determination is provided in Sections 1.3.3.3.7 (Floods) and 3.3.4.4 (Flooding) of the SER (Ex. NRC001). Based on this evaluation, the Staff found that GLE's approach of using the probable maximum flood to estimate design basis flood is acceptable because FCSS-ISG-08 states that deterministically defined events such as the probable maximum flood or safe-shutdown earthquake can be applied to 10 CFR Part 70 facilities as "highly unlikely" events. The ISG further states that "[f]or

the purpose of determining appropriate values of extreme events, deterministic events such as the probable maximum flood or safe-shutdown earthquake can be used in place of purely probabilistically determined ‘highly unlikely‘ events and may be preferable, depending on the quality of historical data.” (Ex. NRC036 at 16). Based on this guidance, the Staff accepted the approach of using the probable maximum flood, the probable maximum precipitation, and the probable maximum hurricane surge to assess the flooding impact at the site.

The design basis probable maximum flood water level is 8.5 m (28 ft) above mean sea level. The proposed facility is located 7.6 m (25 ft) above mean sea level. This elevation is, in general, the highest level east of the Northeast Cape Fear River, and is at about the same elevation as the area west of the river for some distance. The site and the surrounding area are relatively flat with gently sloping surfaces at gradients less than 2 percent with little relief. Because of the availability of a large flat region to accommodate flood waters, the probable maximum flood reaches the elevation much more than 7.6 m (25 ft) is very unlikely. Therefore, the design basis flood level of 8.5 m (28 ft) above mean sea level is conservative.

The Staff evaluation of the potential flooding from hurricanes and tsunamis is provided in Sections 1.3.3.3.2 (High Winds and Hurricanes), 1.3.3.3.8 (Tsunami), and 3.3.4.2 (Hurricane and Tsunami) of the SER and is discussed further in the Staff’s responses to questions 10 and 11 in the NRC Staff Public Responses to the Licensing Board’s Initial Questions Regarding the SER (Ex. NRC007 at 14-18). As indicated in the staff’s response to the Board’s initial question No. 10 (Ex. NRC007 at 14-16), the estimated probable maximum hurricane storm surge at the open-coast shoreline of North Carolina is 6.7 m (21.9 ft) using the probable maximum hurricane as per RG 1.59 (Ex. NRC029). Using the probable maximum hurricane to estimate hurricane-induced storm surge is acceptable because it is consistent with the approach suggested in FCSS-ISG-08 (Ex. NRC036). In addition, GLE’s assumption that this level of surge could reach the facility site without considering possible dissipation adds conservatism to the estimate; the facility is located approximately 32 km (20 mi) upstream from the estuary of Cape Fear River

and is more than 16 km (10 mi) away from the nearest coastline. The design basis flood water level [8.5 m (28 ft)] for the site bounds the flooding from hurricane; therefore, the design basis is conservative relative to the flooding hazards from hurricanes.

As stated in the Staff's response to the Board's initial question No. 11 (Ex. NRC007 at 16-18), the probability that a large tsunami with an inundation distance greater than 16 km (10 mi) would reach the facility site is highly unlikely because the plate tectonic conditions along the Atlantic seaboard are not conducive to forming large earthquake-generated tsunamis. The Atlantic coast of North Carolina is not a subduction zone (Ex. NRC039) and there are no large submarine volcanoes offshore. Subduction zones in the Caribbean and at the Scotia island arc chain (South Sandwich Islands) near Antarctica are too distant to significantly impact the North Carolina coast. The fractures discovered along a 40-km (25-mi) stretch of the continental shelf, off the Virginia and North Carolina coastlines, could trigger tsunami with a surge similar to a storm surge resulting from Category 3 or 4 hurricanes (Ex. NRC038 at 410). There is some evidence to suggest that a large undersea landslide at this continental shelf occurred approximately 18,000 years ago. However, there are no historical records of tsunamis along the North Carolina coastal area since colonial settlement about 1690 (Ex. NRC037 at 10). The tsunami wave size similar to Category 3 or 4 hurricanes is bounded by the estimated probable maximum hurricane storm surge. Because the design basis flood water level of 8.5 m (28 ft) for the site bounds the estimated probable maximum hurricane storm surge, it bounds the estimated tsunami surge (equivalent to that from a Category 3 or 4 hurricane) as well. Therefore, the design basis flood is adequately conservative relative to the flooding hazard from tsunamis.

Operational safety is further enhanced by (i) GLE's plan to mitigate the flooding hazard using personnel evacuation and shutdown of facility processes prior to any potential threat of flooding and (ii) GLE's use of the AISC N690, "Specification for Safety-Related Steel Structures for Nuclear Facilities," ASCE 7-05, "Minimum Design Loads for Buildings and Other Structures,"

and ACI-349, “Code Requirements for Nuclear Safety-Related Concrete Structures (ACI 349-06) and Commentary” codes and standards to design IROFS structures to mitigate the flooding hazard. The elastic design using the nuclear facilities design codes and standards will provide significant reserve strength associated with the analysis, load combinations, and design of steel and reinforced concrete structures.

High Wind and Tornado Hazards

Q9: Briefly review the Applicant’s high wind and tornado hazard evaluation.

A9: (AC, SH) GLE discussed high wind and tornado hazards in ISA Summary Sections, 2.5.5 (Hurricanes) and 2.5.6 (Tornadoes) (Ex. GLE010). The highest 3-second wind gust recorded was approximately 172 kilometers per hour (km/hr) (107 miles per hour (mph)) measured at the New Hanover County airport (Wilmington International Airport). Based on this information, GLE concluded that hurricane winds define the design basis wind speed. Because no Category 4 hurricanes have ever been reported for the area, GLE selected a Category 4 hurricane with a 3-second gust wind speed of 253.5 km/hour (157.5 mph) as the deterministically identified “highly unlikely” event for the facility site. Historically only six Category 4 and six Category 5 hurricanes were recorded with wind speeds greater than 253.5 km/hour (157.5 mph) at landfall. Landfall of these hurricanes took place either on the coast of the Gulf of Mexico or in southern Florida, which are both at least 805 km (500 mi) from the coast of North Carolina. Hurricane Hugo in 1989 made landfall north of Charleston, South Carolina with a 3-second gust wind speed of approximately 245 km/hr (152 mph), which is less than the 253.5 km/hour (157.5 mph) design basis wind speed the applicant defined. Category 4 Hurricane Hazel in 1954 made landfall just south of the North/South Carolina border approximately 64 km (40 mi) from the proposed site. At landfall, Hurricane Hazel was at Category 3 strength with an estimated 3-second gust wind speed of 225 km/hour (140 mph).

Q10: Expand on the rationale behind the NRC Staff's conclusion that the evaluation of these hazards was acceptable.

A10: (AC, SH) The Staff's evaluation of the high wind and tornado hazards is documented in Sections 1.3.3.3.1 (Tornado Hazard), 1.3.3.3.2 (High Winds and Hurricanes, and 3.3.4.1 (High Wind and Tornado Hazards) of the SER (Ex. NRC001). Based on 58 years of available published data, 15 tornadoes were recorded between 1950 and 2004 in New Hanover County. The strongest tornado was rated F2 on the Fujita scale and occurred in neighboring Brunswick County. No F4 and F5 tornadoes were recorded in North Carolina and all tornadoes that occurred in the Wilmington area were either F1 or F0 tornadoes. Guidance in NUREG/CR–4461 (Ex. NRC030 at 8-1) recommends a design wind speed of 180 km/hour (112 mph) for a "highly unlikely" tornado with an annual probability of 10^{-5} for the region where the proposed facility is located. This tornado wind speed is less than the wind speed of 253.5 km/hour (157.5 mph), the design basis wind speed, for the "highly unlikely" Category 4 hurricane.

GLE estimated the design basis wind speed of 253.5 km/hr (157.5 mph) based on the wind speed of a Category 4 hurricane. The design basis wind speed that GLE selected is conservative for several reasons. First, this design basis wind speed is greater than the upper bound wind speed for a Category 3 hurricane (3-second gust wind of 211–249 km/hour (131–155 mph)). No hurricane winds with the Category 3 or 4 hurricane strength have even been reported in the area. Second, the wind speed of a hurricane will decrease once it makes landfall and is expected to continue to decrease as it travels further inland. Because the proposed site is 16 km (10 mi) inland, the expected wind speed at the proposed site will be smaller than that at the landfall area. For example, Hurricane Fran was a Category 3 hurricane when it made landfall on the North Carolina coast near Cape Fear on September 5, 1996 with a 3-second gust wind speed of 203 km/hour (126 mph). However, the 3-second gust wind speed of Hurricane Fran measured at the Wilmington International Airport peaked at approximately 138 km/hour (86 mph). Therefore, selection of the design basis wind speed of 253.5 km/hour

(157.5 mph) is conservative for high wind and hurricane hazards. Third, as discussed earlier in this response, the "highly unlikely" tornado for the site has a wind speed of 180 km/hour (112 mph). This tornado wind speed is substantially below than the design basis wind speed selected for the facility design. Therefore, for the reasons discussed above, the design basis wind speed is adequately conservative for hurricane, high wind, and tornado hazards.

In addition, GLE will convert the high wind and tornado hazards design bases to applied loads to the IROFS structures in accordance with procedures of ASCE 7-05. The applicant will design IROFS steel structures using the allowable design method in AISC N690 and IROFS concrete structures using the ACI 349 design codes. The wind load design using these codes and standards includes inherent design margin.

Earthquake Hazards

Q11: Briefly review the Applicant's earthquake hazard evaluation.

A11: (JS) GLE discussed the earthquake hazard in ISA Summary Section 2.5.1 (Earthquake) (Ex. GLE010). The earthquake hazard evaluation was comprised of three parts: historical seismic record, USGS probabilistic seismic hazard assessment, and the response of the earthquake energy to site soil conditions. First, GLE provided a synopsis of the historical earthquake record for the site and the southeastern United States with the aim of identifying the largest historical local and regional earthquakes. The nearest major seismic event was the large earthquake that struck near Charleston, South Carolina in 1886, with a maximum Modified Mercalli intensity (MMI) of X at the epicenter and an estimated magnitude of 7.3 (Exs. NRC033 and NRC035). The Charleston earthquake epicenter is located approximately 240 km (150 mi) southwest of the proposed facility site. Paleoseismic information indicates similar earthquakes shook the Charleston, South Carolina, region several times over the past several thousand years (Ex. NRC033). A repeat of the Charleston earthquake is considered the most significant source of the seismic hazards for the southeast coast of the United States, including

Wilmington, North Carolina (Ex. NRC032 at 40-46). Estimates of repeat times for a Charleston earthquake range between 250 and 1,000 years (Ex. NRC033). The two largest recorded earthquakes in the local region around the site occurred on January 18, 1884, and again on March 5, 1958. No substantial damage was reported from either earthquake. Press reports indicate that houses shook and some people were rolled out of bed, suggesting that these two earthquakes had MMI values of V or less (Ex. NRC035). These events are estimated to have moment magnitudes of M3.5 or less.

Second, GLE provided the probabilistic ground motions predicted for this site based on the 2008 USGS National Seismic Hazard Maps. GLE cited the USGS maps for a 2 percent probability in a 50 year period of exceeding, which is approximately equal to a return period of 2,500 years or an annual probability of 4×10^{-4}. Building code requirements in the 2006 International Building Code (IBC) (Ex. NRC034) specify that the building should be designed to withstand 2,500 year return period ground motions. These USGS ground motions predicted for the site exceed those that resulted from any of the historical earthquakes. It is important to note that establishing the seismic design basis is only first step in developing adequate assurance the items relied on for safety (IROFS) will maintain their safety functions under the demands imposed by earthquake ground motions. The design methods (e.g., appropriate use of nuclear grade codes and standards) play a vital role in establishing the capacity of the IROFS beyond the design basis. In this case, GLE defined the highly unlikely threshold at less than 1 in 10,000 (10^{-4}). The design methods prescribed in DOE-STD-1020 (Ex. NRC031) or ASCE 43-05 provide sufficient margins such that the IROFS will maintain their safety function (i.e., will meet the performance objectives) for the 10,000 year return period ground motions. DOE-STD-1020 quantifies this excess capacity as a risk reduction factor. In the DOE classification scheme, fuel fabrication and uranium enrichment facilities are designated as PC-3 structures. PC-3 structures are designed using the 2,500 year return period ground motions, but have a risk

reduction factor of at least 4, meaning that they have sufficient capacity so that they will withstand the 10,000 year return period ground motions (4 × 2,500 = 10,000).

Third, GLE provided an assessment of the site soil conditions that could cause local amplification of the earthquake energy and determined that the site is Class C, according to the USGS soil classification system. The USGS map results are based on an assumed “firm rock” site conditions (Site Class B) with a shear wave velocity of 760 m/s (2,500 ft/s). To account for the softer soil conditions at the site, GLE used site amplification coefficients from International Building Code (IBC) (Ex. NRC034) to derive design basis ground motions.

Q12: Expand on the rationale behind the NRC Staff’s conclusion that the evaluation of these hazards was acceptable.

A12: (JS,AC). For the proposed GLE facility, GLE agreed to rely on a more conservative approach to seismic hazard assessment and seismic design than the one described in FCSS-ISG-08 (Ex. NRC036). The Staff’s review of GLE’s approach to seismic hazard assessment is documented in Section 3.3.4.10 (Geologic and Seismic Events) of the SER (Ex. NRC001). There are several reasons to support the Staff’s conclusion that the seismic hazard assessment was conservative.

First, the Staff recognized that deterministic approach developed in FCSS-ISG-08 (Ex. NRC036) was not appropriate in this case because it would have led to a seismic design roughly equivalent to the 1,000-year return period earthquake. As described in Section 2.5.1.4 of the ISA Summary (Ex. GLE010), GLE developed their initial seismic design based on a M6.9 earthquake located 114 km (71 mi) from the site (repeat of the 1886 Charleston event, which is the largest event at large distance from the proposed facility) and a M5.0 event located 20 km (12 mi) from the site (this is the bounding value for seismic activity in proximity to the proposed facility, given that the largest recorded local earthquake had a magnitude of about M3.5). By adapting their approach and instead using the USGS 2,500-year return period probabilistic

ground motions, GLE's design ground motions are greater than those predicted from the historical record and those based on the methods described in FCSS-ISG-08.

Second, GLE will conduct seismic analyses of the IROFS structures by using one or more of the seismic analyses methods permitted by ASCE 7-05. GLE will use the U.S. Department of Energy (DOE) standard, DOE-STD-1020 (Ex. NRC031), AISC N690 and ACI 349 for seismic design of the IROFS structures. By using design methods that rely on these codes and standards, the IROFS structures will be constructed with sufficient capacity to withstand ground motions from earthquakes that are substantially less likely than the design basis ground motions. The risk reduction for the proposed GLE Facility is estimated to be at least four times the design values, leading to a failure probability of 10^{-4} or smaller and consistent with GLE's definition of highly unlikely.

Third, even beyond the highly unlikely failure probability, there is the potential for additional capacity to maintain safety. The failure probability assumes only that an initial failure state is reached. But this failure state may not lead to a complete loss of safety. For example, damage to the building from a highly unlikely earthquake (one with an exceedance probability of less than 10^{-4}) may cause non-elastic damage, such a cracking or tilting, without actual building collapse. Thus, even if the building was damaged in such a scenario, the IROFS in the building may not be damaged and thus could still maintain their safety function.

Q13: Does this conclude your testimony?

A13: (JS, AC, SH) Yes.

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	)	June 18, 2012
(GLE Commercial Facility)	)	

AFFIDAVIT OF ASADUL H. CHOWDHURY

I, Asadul H. Chowdhury, do hereby declare under penalty of perjury that my statements in the foregoing testimony and my statement of professional qualifications are true and correct to the best of my knowledge and belief.

Asadul H. Chowdhury

Executed at San Antonio, Texas
this 18th day of June, 2012

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	)	
	)	June 18, 2012
(GLE Commercial Facility)	)	

AFFIDAVIT OF SUI-MIN HSIUNG

I, Sui-Min Hsiung, do hereby declare under penalty of perjury that my statements in the foregoing testimony and my statement of professional qualifications are true and correct to the best of my knowledge and belief.

Sui-Min Hsiung

Sui-Min Hsiung

Executed at San Antonio, Texas
this 18th day of June, 2012

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	Docket No. 70-7016-ML
	)	
GE-HITACHI GLOBAL LASER ENRICHMENT LLC	)	ASLBP No. 10-901-03-ML-BD01
	)	
	)	June 18, 2012
(GLE Commercial Facility)	)	

AFFIDAVIT OF JOHN A. STAMATAKOS

I, John A. Stamatakos, do hereby declare under penalty of perjury that my statements in the foregoing testimony and my statement of professional qualifications are true and correct to the best of my knowledge and belief.

John A. Stamatakos

Executed at Rockville, MD
this 18th day of June, 2012

Asadul H. Chowdhury
Statement of Professional Qualifications

CURRENT POSITION

Staff Engineer
Center for Nuclear Waste Regulatory Analyses
Geosciences and Engineering Division
Southwest Research Institute
San Antonio, Texas

EDUCATION

Ph.D., Structural Mechanics, Cornell University, 1974
M.S., Structural Mechanics, Cornell University, 1971
B.S., Civil Engineering, East Pakistan University of Engineering & Technology (now Bangladesh University of Engineering and Technology), 1966

PROFESSIONAL

Registered Professional Engineer, Ontario, Canada
Earthquake Engineering Research Institute (EERI)
American Society of Civil Engineers (ASCE)
American Concrete Institute (ACI)
ASCE, ACI, and EERI Technical and Design Code Committee Member

QUALIFICATIONS

Dr. Chowdhury is a structural engineer with more than 35 years of teaching, research, consulting, and industrial experience in the areas of structural and geotechnical engineering. He has conducted structural and geotechnical research under seismic, blast, impact, and thermal loads. His studies include field and laboratory investigations and modeling on a variety of structural and geotechnical engineering systems and components. Dr. Chowdhury is particularly experienced in evaluating the analysis, design, and operations of various nuclear facilities dealing with the enrichment of uranium; fabrication of nuclear fuel; spent fuel storage; and storage, handling, and disposal of high-level radioactive waste. He is experienced in conducting numerical analysis of components of nuclear power plants. Dr. Chowdhury is very experienced with the design codes and standards for the design of structural and foundation systems of nuclear facilities, with special emphasis on seismic design. Dr. Chowdhury is well experienced in conducting construction inspection of nuclear facilities

Dr. Chowdhury has managed a team of experts in structural, mechanical, geotechnical, and mining engineering; rock mechanics; and risk and reliability analysis; providing research and technical services in geotechnical and facility engineering and infrastructure areas. He has conducted research in the areas of seismic rock mechanics involving discrete and finite element numerical studies, full and small scale experimental studies, and field investigations of weapons effects and rockburst-induced seismic effects; structural analyses of transportation and storage casks subjected to explosive and missile loads; and analyses of building structures under aircraft crash impact and seismic loads, including soil-structure interaction analysis. Dr.

Chowdhury contributes to safety evaluation reports for licensing and renewal of independent spent fuel storage installations, the Yucca Mountain repository, and fuel cycle facilities.

Before joining Southwest Research Institute, Dr. Chowdhury worked in the nuclear power plant industry, leading a group of structural and mechanical engineers for conducting seismic, dynamic, and thermal analyses of piping systems and the torus of a boiling water reactor, including design to ASME Boiler and Pressure Vessel Codes. He provided technical support to users of proprietary piping analysis and design computer programs. In the field of soil/rock mechanics, Dr. Chowdhury's emphasis has been in the analysis and design of underground openings subjected to transient loads such as seismic, dynamic, impact, and shock loads; nuclear weapons effects; and transient thermal loads. He worked on various other projects such as Repository Design in Basalt, Deep Underground Openings Under Nuclear Weapons Effects (sponsored by Defense Threat Reduction Agency), and Effects of Explosion of Penetrating Projectile on Underground Structures (sponsored by Air Force Office of Scientific Research).

Dr. Chowdhury is the author/co-author of over 125 technical papers and reports.

Sui-Min (Simon) Hsiung
Statement of Professional Qualifications

CURRENT POSITION

Staff Engineer
Center for Nuclear Waste Regulatory Analyses (CNWRA®)
Geosciences and Engineering Division
Southwest Research Institute® (SwRI®)
San Antonio, Texas

EDUCATION

1984 Ph.D., Mining Engineering, West Virginia University
1979 M.S., Rock Mechanics, National Cheng Kung University
1974 B.S., Mining Engineering, National Cheng Kung University

PROFESSIONAL

International Society of Rock Mechanics

QUALIFICATIONS

Dr. Hsiung is a mining engineer with a broad range of experience in geotechnical engineering, integrated safety analysis, and natural phenomena and human-induced hazard assessments. He has more than 35 years of research and consulting experience in the disciplines of mining engineering and rock mechanics. For the last 30 years, Dr. Hsiung has conducted research and provided technical assistance in rock mechanics, geotechnical engineering, and natural phenomena and human-induced hazard assessment to the U.S. Nuclear Regulatory Commission (NRC) and other clients.

Dr. Hsiung worked on numerous research and consulting projects included solving practical ground control problems, designing longwall chain and yield pillars, evaluating room-and-pillar and multiple seam mining practices, investigating interactions of hydraulic power supports with rock strata of underground coal mines, and monitoring to support abandoned mine subsidence abatement. He also was responsible for a number of field investigations of entry roof deformation, roof strata movement at the longwall face, pillar stability, effectiveness of roof supports and hydraulic power supports, and surface subsidence induced by longwall mining.

At the Geosciences and Engineering Division of SwRI, Dr. Hsiung provided technical support to NRC on license application reviews of fuel cycle facilities. His experience includes (i) reviewing structural designs for mixed oxide and gas centrifuge facilities; (ii) developing safety evaluation reports for NRC on several license applications for mixed oxide, gas centrifuge, laser enrichment, and independent spent fuel storage installation facilities with focuses on tornado and high-wind evaluation; slope stability, liquefaction potential, aircraft crash, snow, and hurricane hazard characterizations; tornado and human-made missile impact assessments; settlement and soil bearing capacity determinations; (iii) performing final structural design review (including foundation design and soil-structure interaction analyses) and construction inspections on gas centrifuge facilities; and (iv) reviewing several integrated safety analysis summaries for the NRC-licensed nuclear fuel fabrication facilities.

Dr. Hsiung also provides technical support on performance and design review of a potential high-level waste geologic repository, including conduct of independent site-response and soil-structure interaction analyses. He lead an effort of conducting soil-structure interaction analyses of a hypothetical waste handling facility to investigate the effects of characteristics of seismic ground accelerations, soil spatial variations, and soil geotechnical properties on structural seismic responses. In conducting the soil-structure interaction analyses, he also assessed the effects of key modeling parameters on analysis results. Dr. Hsiung has significantly contributed to (i) the design of a direct shear apparatus for dynamic experiments on large specimens, (ii) development of a rock joint constitutive model to better describe the dynamic joint behavior observed from laboratory experiments, (iii) field instrumentation and investigation of the effects of mining-induced seismicity on excavation response and local hydrology, and (iv) a small-scale (similitude) rock mass model experiment under scaled earthquake loads. He was a lead investigator in thermal-mechanical-hydrologic modeling of the U.S. Department of Energy Drift Scale Heater Test under the international cooperative program DECOVALEX, developed an analytic relationship to assess effects of joint deformation on joint hydraulic conductivity, and developed a methodology to predict rockbursts in deep underground mines. Dr. Hsiung has developed technical evaluation reports for uranium tailings, reclamation plans for source material licenses in areas related to dynamic and static stability of slopes, potential liquefaction of foundation soils, and settlement effects on radon barrier integrity.

Dr Hsiung has authored over 130 technical papers and reports.

John Stamatakos
Statement of Professional Qualifications

CURRENT POSITION

Director of the Rockville Office and Technical Programs
Center for Nuclear Waste Regulatory Analyses (CNWRA)
Geosciences and Engineering Division
Southwest Research Institute™ (SwRI™)
1801 Rockville Pike, Suite 105, Rockville, Maryland 20852

EDUCATION

Ph.D., Geology, Lehigh University, Bethlehem, Pennsylvania (Geology)
M.S., Geology, Lehigh University, Bethlehem, Pennsylvania (Geology)
B.A., Geology, Franklin and Marshall College, Lancaster, Pennsylvania

PROFESSIONAL

Geological Society of America, Member
Seismological Society of America, Member

QUALIFICATIONS

Dr. Stamatakos is a structural geologist and geophysicist with international research experience. His areas of expertise include paleomagnetism, magnetostratigraphy, paleogeography, exploration geophysics, neotectonics, and earthquake seismology. Dr. Stamatakos applies his expertise to investigations of seismic sources in earthquake hazard studies; kinematics of fault block rotations in strike-slip, normal, and thrust fault systems; effects of internal strain on the magnetic properties of deformed rocks; evolution of curvature in arcuate mountain belts; and age and sequence of deformation in folded and faulted mountain belts. He brings a global perspective on structural geology, having conducted investigations in the Basin and Range in the western United States, the northern and central Appalachians in the eastern United States and Canada, the Hercynian mountains in Germany and northern Spain, and the northern Cordilleran Mountains in Alaska.

Dr. Stamatakos serves as the director of technical programs for the CNWRA and provides technical support to tectonics research at CNWRA, including geologic and geophysical analyses of the tectonic elements of the Basin and Range province in southwestern United States, evaluation of seismic hazards at nuclear facilities, and development of tectonic models. These U.S. Nuclear Regulatory Commission (NRC)-sponsored investigations support evaluations of earthquake and volcanic risks at critical nuclear facilities. Dr. Stamatakos has provided technical reviews on seismic hazard and seismic design for a number of NRC-licensed facilities in Nevada, Utah, Idaho, California, Ohio, Kentucky, and South Carolina. He has provided expert testimony on seismic and volcanic issues on behalf of the NRC staff before the Atomic Safety Licensing Board. In addition, Dr. Stamatakos administers the Rockville Office as an offsite facility of the division, with the preponderance of its functions and uses being on behalf of Center for Nuclear Waste Regulatory Analyses (CNWRA®). Dr. Stamatakos manages and provides day-to-day interfaces with the NRC on CNWRA projects.

Before joining Southwest Research Institute, Dr. Stamatakos held positions of visiting faculty at the University of Michigan and postdoctoral fellow at the Eidgenössische Technische Hochschule in Zurich, Switzerland. At the University of Michigan, Dr. Stamatakos taught courses in field mapping, structural geology, geophysics, and tectonics.

Dr. Stamatakos has written or collaborated on more than 60 papers and reports on structural geology, tectonics, and geophysics. He has made presentations at international conferences in the United States, Canada, and Europe and has won an outstanding paper award from the American Geophysical Union. Dr. Stamatakos is past associate editor of the Geological Society of America Bulletin, and has served as a regular reviewer of papers for the Journal of Geophysical Research, Earth and Planetary Science Letters, Reviews of Geophysics, Journal of Structural Geology, Physics of the Earth and Planetary Sciences, and Geophysical Research Letters, as well as for grant proposals for the National Science Foundation.projects.